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ABSTRACT

Since the 1960's biology teaching in secondary schools has been transformed from a formal approach reflecting the structure of the discipline and mirroring the concerns of the scientific community to a broad-based approach reflecting the concerns of society as a whole. The aim of biology education today is to heighten awareness, improve students' self-image, understand the applications of biology in daily living, and promote participation in societal decision making in areas such as science policy and in other socially significant matters with a basis in biology. This book attempts to review aspects of this transformation and to describe exemplars and case studies of curriculum trends, teaching methods, and assessment procedures which reflect the transformation. Chapters include: (1) "Challenges for Biology Education"; (2) "Curriculum Themes"; (3) "Curriculum Structures"; (4) "Biology For General Education"; (5) "Selection of Curriculum Themes and Structures for General Education"; (6) "Meeting Immediate Personal Needs"; (7) "Meeting Immediate Community Needs"; (8) "Developing Needs-Biology Topics with a Future Orientation"; (9) "Continuous Assessment"; (10) "Assessing Cognitive Achievement"; (11) "Assessing Attitudes, Interests, and Values"; (12) "Assessing Manual Skills"; (13) "The Issue of Public Examinations"; (14) "School Facilities and Resources"; (15) Facilities and Resources Outside the School"; (16) "Curriculum Development"; (17) "Design of Learning Material"; and (18) "Teacher Development." (JRH)

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TEACHING SECONDARY BIOLOGY FOR SOCIAL RELEVANCE

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TEACHING SECONDARY SCHOOL BIOLOGY
FOR SOCIAL RELEVANCE

by

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with introductory chapters by

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1995

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Beecroft Australia

Chapter 1

INTRODUCTION - CHALLENGES FOR BIOLOGY EDUCATION

1.1 The Changing Nature and Purpose of Biology Education

Since the 1960s biology teaching in secondary schools has been transformed from a formal approach reflecting the structure of the discipline and mirroring the concerns of the scientific community to a broad-based approach reflecting the concerns of society as a whole. This change has come about as a result of several challenges to biology educators, some from rapid progress made within biology itself and some from a community demand to make biology teaching more relevant to the needs of pupils and the needs of the community at large (1).

The purpose of teaching biology has changed. In the first half of the century most programmes of secondary school biology aimed to prepare a select group of pupils for further studies - an academic orientation. Today the purpose is to make all citizens biologically literate. The aim is to heighten awareness, improve one's self image, understand the applications of biology in daily living and promote participation in societal decision making in areas such as science policy and in other socially significant matters with a basis in biology.

This volume attempts to review aspects of this transformation and to describe exemplars and case studies from throughout the world of curriculum trends, teaching methods and assessment procedures which reflect the transformation. This first chapter reviews some of the recent challenges to biology education and comments on their current and longer term impact.

1.2 Biology Education, Biological Literacy and Societal Development

Biology education in secondary schools has been subjected to a series of pressures or challenges due to changes within biology itself and to changes in related areas and in society at large. These pressures and challenges include the following. They are considered in more detail in section 1.3 below.

- Advances in the science of biology - especially in fields such as biotechnology, reproductive physiology and genetics.

- Changing views about the nature of science, scientific processes and the characteristics of the scientific community.

- The applications of biology in socially sensitive matters such as family planning, environmental management, and so on.
- A growing awareness in the community about sensitive bioethical issues such as abortion, euthanasia and animal liberation.
- The rapid growth of information technology and the intrusion of computers into almost every aspect of daily life.
- Greater community sensitivity to environmental matters such as the degradation of rain forests, pollution, population growth and the greenhouse effect.
- Greater awareness in society at large of the need to conserve energy and to find alternative sources of energy.
- An increased demand that national and international economic, social and human development should be systematically planned so as to be sustainable.
- A growing demand that education should be accountable in terms of helping to satisfy genuine human needs.
- Improvements in technologies available to educators so as to make teaching more efficient and effective.

These pressures have brought about profound changes in the content, methodology and assessment procedures of school biology programmes throughout the world. The content is more broadly based and socially oriented; the methodology focuses on the processes of science and also draws in methods of teaching once thought to be the prerogative of the social sciences, and assessment procedures have focussed more on inquiry, critical thinking, evaluation of options and understanding of applications in the real world.

This change is more advanced in some parts of the world than in others but everywhere the trend is the same (2). Secondary school pupils, and indeed the populace as a whole, is becoming more biologically literate. Biological literacy, like any type of scientific literacy, is generally considered to have three components (3). The first is a knowledge component. The challenges listed above and discussed below in section 1.3 suggest that the biological knowledge required today has little to do with life cycles and structures and classification systems studied for their own sake and has much to do with societal problems and issues, biologically based social matters, a consideration of bioethical dilemmas and information about economic, personal and social development.

The second component of biological literacy reflects the nature of science itself - the way scientific discoveries are made, the nature of inquiry, the characteristics and limitations of scientific explanation and so on. Related to this is for a biologically literate person to understand the characteristics of the scientific community and how scientists operate within that community and in society at large. It is clear that this component of biological literacy emerges as a resultant of several of the challenges faced today by biology educators.

The third component of scientific literacy is not just to know and understand social applications of biology but to be able to actually apply biological concepts and processes in daily living. In particular this aspect of biological literacy implies that all citizens should be active participants in determining local, national and even world-wide policies in regard to science-based matters. Decision making based on reasoned understanding and rational thinking is a prerequisite for effective democracy and so this dimension of biological literacy involves critical thinking, the ability to resolve conflicts, the ability to solve problems, to undertake rational argument and to plan systematically and effectively for personal life and for the growth of society as a whole.

If a community is generally literate and especially if it is scientifically and biologically literate, then its citizens are in a position to develop personally satisfying philosophies of life, to plan their lives effectively, to contribute democratically to the determination of policies at all levels, to apply their education to daily living and to contribute to satisfying personal growth and to sustainable economic, human and social development.

The ideas outlined above are summarised in figure 1.1. The remainder of the chapter reviews in more detail the challenges to biology education listed in this section.

1.3 The Specific Challenges to Biology Education

The challenges listed above in section 1.2 have affected how biology courses are designed and taught in virtually every school system of the world. It is not surprising, however, that the resultant programmes differ greatly from school system to school system. Inevitably some school systems, say those in the more economically advanced regions, will be influenced most by changing technologies such as biotechnology, information technology and the impact of economic development on the environment. Other school systems in the less developed regions of the world may respond more to meeting basic human needs and to improving quality of life through their biology courses.

While this variation does occur, it is also true to say that almost no modern course of school biology has remained unaffected by these pressures. In most cases, though, the responses have been relatively unsystematic and therefore the educational outcomes have been somewhat diffuse. One purpose of this volume is to help

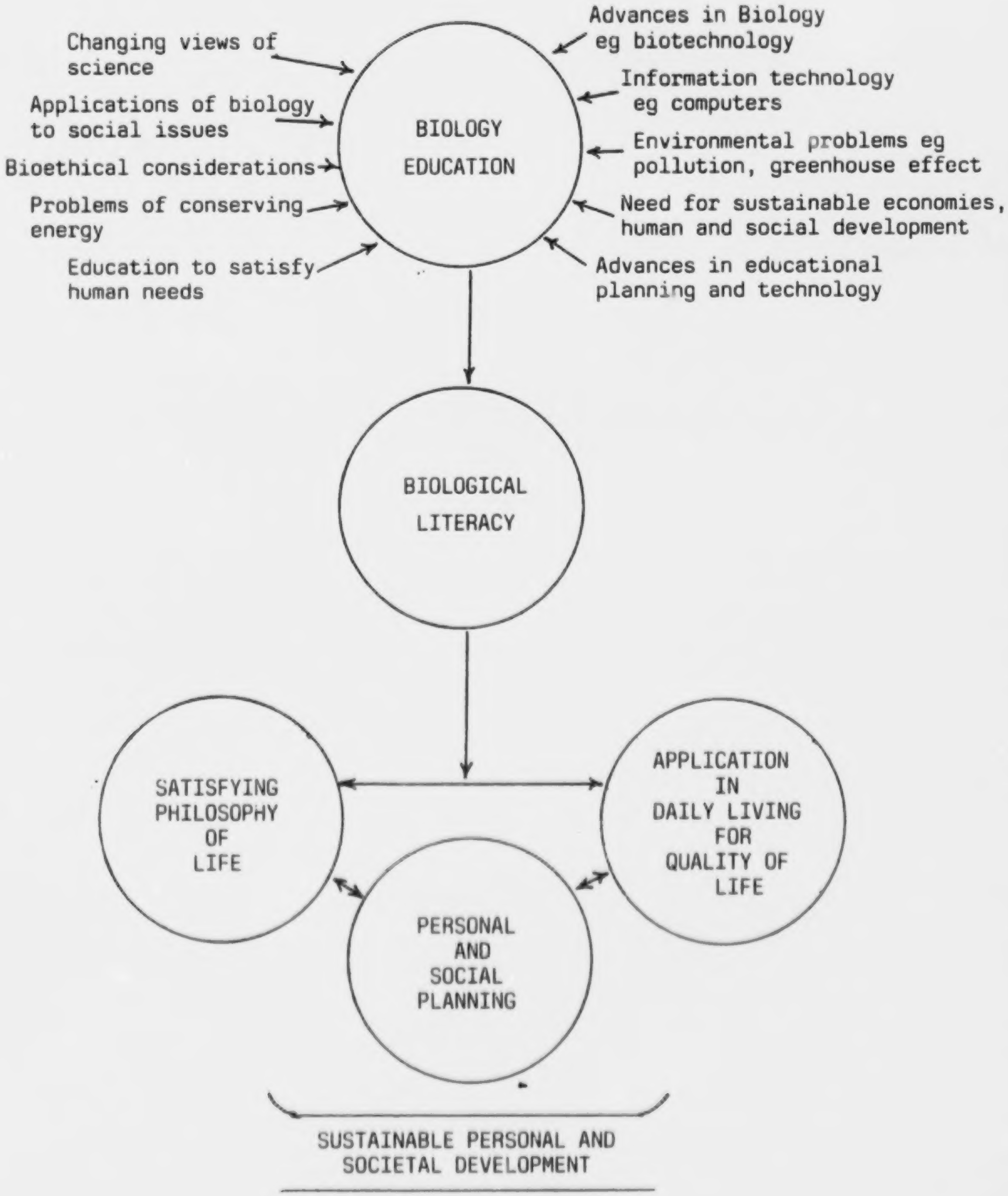
Changing views of science
Applications of biology to social issues
Bioethical considerations
Problems of conserving energy
Education to satisfy human needs
Advances in Biology eg biotechnology
Information technology eg computers
Environmental problems eg pollution, greenhouse effect
Need for sustainable economies, human and social development
Advances in educational planning and technology
BIOLOGY EDUCATION
BIOLOGICAL LITERACY
SATISFYING PHILOSOPHY OF LIFE
APPLICATION IN DAILY LIVING FOR QUALITY OF LIFE
PERSONAL AND SOCIAL PLANNING
SUSTAINABLE PERSONAL AND SOCIETAL DEVELOPMENT

Figure 1.1. Challenges to Biology education and the outcomes of an effective response to these challenges.

educational planners, curriculum designers and teachers understand these processes more clearly so as to make their school biology programmes more in tune with present needs.

i) Challenge 1. Advances in Biology. Since the 1950s and the discovery of the genetic code, biology has rapidly advanced from a descriptive science to a technologically based complex of interacting subdisciplines. Central to this change has been the emergence of biotechnology based on DNA recombination techniques. This has allowed genetic engineering to emerge with the possibility of producing insulin, growth hormones, vaccines and other products through the manipulation of genes. Recently (1989) the mapping of the entire human genome has begun. Other areas of rapid advance have included greater understanding of how ecosystems work and the development of more comprehensive models to explain the processes of evolution. In the area of human physiology there is a clearer knowledge of how the nervous system functions. New insights into immunology have allowed developments such as organ and tissue transplants and have helped in the search for a cure for AIDS. In the area of reproductive physiology invitro fertilization techniques are now well established making possible practices such as surrogate motherhood and the long-term storage of sperm and ova. These and other trends within biology itself have had to be reflected in biology teaching at school. In particular modern genetics and biotechnology are now widely taught and have greatly changed the way biology is oriented giving it a strong experimental and technological emphasis (4).

ii) Challenge 2. Changing Views About the Nature of Science. In recent years philosophers and sociologists have re-examined many aspects of the scientific process. Today science is seen by most as a changing product of society and not of a set of immutable rules and processes. Philosophers are looking very critically at the nature of scientific explanation and especially at the validity of the inductive-deductive model on which so much of the previous views of science depended (5). What it means to be a scientist and the characteristics of the scientific enterprise are now examined by sociologists (6) and previously held views about the value free objectivity of science have been set aside. These trends have posed a direct challenge to the science educator who now must reconsider basic tenets such as the nature and role of inquiry learning.

iii) Challenge 3. Biology and Social Issues. This is probably the most significant of the challenges. Academic biology taught for its own sake or to prepare school-age pupils for further studies in biology is no longer valid. Instead the community at large has demanded that the content be socially relevant meeting the real needs of pupils and of society at large. This trend was reflected, for example, in the important international conference on "Science and Technology Education and Future Human Needs" held in Bangalore India in August 1985. That conference was sponsored by the Committee on the Teaching of Science (CTS) of the International Council of

Scientific Unions (ICSU). Nine volumes of proceedings were produced covering the following areas:

- Science and technology in relation to needs
- Ethics and social responsibility
- Industry and technology
- Land, water and mineral resources
- Health
- Food and agriculture
- Energy resources
- The environment
- Information transfer.

Clearly this changed emphasis in the content of biology programmes at school level poses a major challenge for curriculum developers. Criteria need to be established and rigorously applied for the selection of appropriate socially oriented themes and for the rejection of inappropriate material. The trend is towards the identification and analysis of biologically based social issues with considerable attention being given to societal problem solving, critical thinking and participatory decision making.

iv) Challenge 4. Sensitivity to Bioethics. The advances in biology together with the trend towards a focus on social issues have challenged biology educators to give prominence to bioethical considerations. Modern society faces many ethical dilemmas. The issue of sustainable development and the torching of rain forests; the conflict between abortion and theories about rights to life; the question of euthanasia; the issue of surrogate motherhood and ethical aspects of experiments with the human foetus are obvious examples of these bioethical considerations. The Education Commission of the International Union of Biological Sciences (IUBS-CBE) has recently produced a book on this problem (7). This book advocates a case history approach to dealing with these sensitive issues and suggests procedures for analysing bioethical conflicts without imposing any particular solutions. The aim is to reduce bias and conflict and to help individuals reach ethically satisfying conclusions using rational and objective methods. Such an approach means not only a significant change in the content of school biology but also in its methods of teaching. Methods previously thought appropriate mainly for the social sciences are now needed for biology. These include a greater reliance on small group discussion, on conflict resolution methods and on case study analysis.

v) Challenge 5. Growth of Information Technology - especially computers. The advent of satellite communications; international, national and local computer networks; advanced computer technology, and the widespread use of personal computers, pose their own challenge for the biology educator. Applications of computers in management and research are self evident and there is a growing range of uses in the direct teaching-learning interface. Both teachers and pupils now need to develop competency in what has come to be termed "computer literacy". This involves two categories of skill - how to use the computer and how to develop programmes. Not all school pupils may need to write programmes but certainly the biology curriculum developer of the future must face this challenge. Commercial programmes of both "tool" and "pedagogical" types may need to be adapted and new programmes developed. In particular many tool type programmes originally developed for the business world have enormous potential in education provided they are suitably modified. In addition specific biotechnological developments such as the biochip need to be taken into account. Already biology educators are responding to these challenges and are suggesting ways computers and other aspects of information technology can be applied in secondary schools (8).

vi) Challenge 6. Community Sensitivity to Environmental Issues. The expansion of environmental education in almost all school systems poses a direct challenge to the biology educator. Unesco-Unep proposes the following key concepts as the main core of environmental education (9).

1. Levels or systems of being - social, biological and physical
2. Natural cycles and their disturbance
3. Environmental systems made up of interconnected "stocks" and "flows"
4. Population growth and carrying capacity
5. Environmentally sustainable development
6. Socially sustainable development
7. Knowledge and uncertainty in environmental planning.

Each of these concepts has direct application in biology teaching and needs to be accommodated in modern programmes of secondary school biology. In addition these concepts have to be linked to challenge 3 "Biology and Social Issues" and to challenge 4 "Sensitivity to Bioethical Issues".

vii) Challenge 7. Conservation of Energy and the Search for Alternatives. The general community is becoming deeply concerned about the problems of obtaining the energy needed for our industrialized society and for maintaining a high quality of life. The rapidly diminishing supplies of non-renewable resources such as oil highlight this problem. The community is increasingly resistant to the idea of nuclear power and seeks safer alternatives such as solar energy and biological sources of energy. School biology courses need to address this issue. For example Unesco has proposed certain curriculum changes which would introduce the concept of biofuels. It is proposed that school biology courses give greater attention to biological pathways which generate biofuels or which conserve biofuels ie nitrogen fixation, methane production, hydrogen production and photosynthesis without chlorophyll (10). What seems to be required is an adjustment to school biology curricula to emphasise not only the scientific aspects of energy sources and applications but also their technological, economic and social implications.

viii) Challenge 8. The Need for Systematic Planning for Sustainable Development. The idea of sustainability which aims to leave "the same or an improved resource endowment as a bequest to the future" (11) is complex and involves the concept of capital wealth. This wealth has been seen in the past to consist mainly of manufactured or engineered items such as machinery, industrial complexes, transport systems and so on and that has been the central concern of economic sustainable development. But there is also environmental wealth which includes the stocks of natural assets and the natural processes such as biogeochemical cycles which sustain them. In addition there is a growing awareness of the importance of human capital - the build up of knowledge and expertise by the human mind. Indeed it is this latter aspect that is a central focus of attention by development planners and UNDP has now created an Index of Human Development (the HDI) to go together with the traditional index of Gross National Product (GNP). Countries can now be classified as having low medium or high HDI. The indicators of HDI include life expectancy, adult literacy level and purchasing power. In a sense, therefore, it is an index of quality of life (12). The achievement of all aspects of sustainable development requires a sensitive understanding of their biological base. It also requires careful and systematic planning.

Clearly as these ideas do have a strong basis in biology biology educators must face the challenge of dealing with them. So far few school biology programmes are totally structured around the idea of sustainable development and its concepts but some programmes do select aspects as examples of biology-based social issues. Greater attention needs to be paid to this area as it requires a more systematic and holistic treatment than it receives at present.

ix) Challenge 9. Education Should be Accountable in Terms of Satisfying Human Needs. As an outcome of the trend to make teaching more relevant, education per se is now held more accountable by the community in regard to satisfying human needs. There is a growing body of research investigating the nature of human needs and how biology education in particular can contribute to satisfying needs (13). The research shows that there are mental, bodily and environmental needs and that these are wide ranging but very variable in intensity. Needs vary considerably from country to country. For example in the area of bodily needs most cultures rate the need for good personal health very highly whereas views about the need for access to good quality food varies considerably according to the level of economic development - in highly developed countries it is not perceived as an issue because the need has been met. The research also shows that most human needs have a basis in biology. It is important therefore that school biology programmes focus on how the subject can help satisfy needs. Also because of the issue of accountability it is equally important that school biology curricula make this emphasis clear and direct.

x) Challenge 10. Teaching has Become More Efficient and More Complex in Terms of its Technology. Biology educators meeting the various challenges outlined above now have available a wider range of educational approaches, resources, technologies and methods of teaching than ever before. The availability of low cost print materials through desk-top publishing, the wide range of approaches to individualizing instruction and to distance education, the availability of technologies such as computers and audio-visual systems, the broadening of the repertoire of teaching methodologies and the improved techniques of assessment and evaluation are just some of the new approaches which come to mind (14). The changing role and purpose of school biology places pressure on course designers and teachers to select the most appropriate of these approaches to achieve the new educational objectives now required of the subject. In particular there is need for a judicial selection of approaches from both the pure science and social science areas.

1.4 Conclusion - International and National Agents of Change

This volume attempts to give an overview of how biology educators world-wide have responded to the above challenges. Exemplars of current practice in terms of curriculum approaches, teaching methods and assessment procedures are outlined.

The information given in the volume comes from two main sources. The first is the response given to a world-wide questionnaire survey of biology teaching undertaken by the author in 1988 and 1989. The second comes from the reports and other documents of international bodies such as Unesco, Unep and other United Nations agencies; the Committee on the Teaching of Science of the International Council of Scientific Unions (ICSU-CTS); the International Union of Biological Sciences (IUBS) and its Commission on Biological Education (IUBS-CBE); the International Council of Associations for Science Education (ICASE); the Biological Sciences Curriculum Study (BSCS); the Asian Association of Biology Education (AABE) and many national science teaching projects such as the Nuffield Ordinary and Advanced Level School Biology Projects in the United Kingdom.

The book is organized in five main sections. The first part deals with curriculum patterns including themes for structuring the curriculum and how curricula world-wide have responded to the challenges outlined in this chapter. The second part is the main part of the book giving a series of exemplars on teaching approaches and methodologies which are relevant to the newly emerging socially relevant objectives. Part Three reviews trends in assessment and gives exemplars of relevant current practice. Part Four reviews the availability of resources for meeting the new challenges and Part Five describes procedures for developing curricula, material resources and personnel.

Notes and References

(1) See for example: Schaefer, G. and Younes, T. (Eds) "New Challenges for Biological Education" *Biology International International Union of Biological Sciences News Magazine* Special Issue No 11 1986. See especially the Foreword pp 1-2.

(2) Meyer, G. Rex *Overcoming Constraints on the Teaching of Biology A Global Perspective*. Jakarta: Unesco-Rostsea 1988.

(3) See for example: Miller, Jon D. "Scientific Literacy: A Conceptual and Empirical Review" *Daedalus* Vol 112 No 2 Spring 1983 pp 29-48.

(4) See for example: McInerney, Joseph D. *Teaching Biotechnology in Schools* (Science and Technology Education Document Series No 39). Paris: Unesco 1990.

(5) See for example: Chalmers, A.F. *What is This Thing Called Science?* Second Edition. St. Lucia Queensland: University of Queensland Press 1982.

(6) A typical approach is given by Blume, Stuart S. *Towards a Political Sociology of Science*. New York: The Free Press 1974.

(7) Meyer, G. Rex *Bioethical Education*. Hamburg: Lit for IUBS-CBE 1991.

(8) See: Crovello, Theodore J. (Ed) *Computors and Biological Education The Expanding Universe*. Paris: The International Union of Biological Sciences 1988. Also see: Badran, Adnan M. "Trends in Computer Applications for Biology Education" *in* G. Rex Meyer (Ed) *Selected Issues in Biological Education*. Hamburg: Lit for IUBS-CBE 1990 pp 67-72.

(9) Unesco-Unep "Basic Concepts of Environmental Education" *Connect Unesco-Unep Environmental Education Newsletter* Vol 15 No 2 June 1990 pp 1-4.

(10) Tribe, Michael and Pritchard, Alan J. *Biological Systems, Energy Sources and Biology Teaching* (Science and Technology Education Document Series No 9). Paris: Unesco 1984.

(11) Pearce, David "An Economic Perspective of Sustainable Development" Development Journal of the Society for International Development 1989 Nos 2/3 p 17.

(12) For an introductory discussion of these ideas see Unesco Proap: Appeal Training Materials for Continuing Education Personnel (ATLP-CE) Volume 1 Draft Edition Chapter 1. Bangkok: Unesco Proap 1990.

(13) See for example Schaefer, Gerhard Basic Human Needs and Their Relevance for Biological Education. A paper presented to the annual meeting of the International Union of Biological Sciences Commission for Biological Education (IUBS-CBE) Nairobi Kenya 26 August-2 September 1990.

(14) See for example Meyer, G. Rex Methodologies for Relevant Skill Development in Biology Education (Science and Technology Education Document Series No 2). Paris: Unesco 1982.

PART I

CURRICULUM PATTERNS

Introduction to Part I

This introductory part of the volume explores present attempts world wide to make secondary school biology more relevant to everyday life. The various challenges outlined in Chapter 1 have been met with varying degrees of success and there is a somewhat precarious balance between teaching biology as the science of life and teaching it as input for daily living.

Chapter 2 reviews dominant curriculum themes which have been used as the main unifying framework for biology courses in various school systems. An attempt has been made to organize the chapter sequentially so that the earlier sections deal with the more conventional "science of life" approaches while the later sections lean more towards social application. Exemplar curricula are cited throughout.

Chapters 3, 4 and 5 are by guest authors. Chapter 3 by Winston K. King of the University of the West Indies reviews alternative curriculum structures such as separate botany and zoology as against integrated biology or unified science. He summarises current trends and shows that the broader more integrated approaches tend to be more suitable for the socially oriented objectives of modern curricula. He nevertheless argues that the balance must be maintained between a need to cater for social applications and a need to prepare students for further studies in biology.

Chapter 4 is by Elvira R. Galvez of the Institute for Science and Mathematics Education Development (ISMED) of the University of the Philippines. Dr. Galvez considers changing trends in school biology within the framework of theories of general education. The general education movement had its origins with John Dewey and later with the progressivists of the 1930s, but it was not until after the Second World War that biology curricula were significantly influenced by this movement. In Chapter 4 examples are cited of how school systems have attempted to focus biology teaching on achieving the broad aims of general education.

Chapter 5, by Professor Mohammed Subbarini of Yarmouk University, Jordan, attempts to bring together the ideas of the previous three chapters by reviewing optimal approaches to relating structural and thematic aspects of the school biology curriculum for the purpose of achieving general educational outcomes. Professor Subbarini presents and discusses useful practical criteria for selecting content and for relating the content to appropriate curriculum structures.

The purpose of Part I is to provide a general framework for reviewing and assessing the more detailed exemplary materials presented in Part II. Part II is the core of the volume as it gives examples of content, activities and assessment items from many parts of the world which reflect the trends and approaches discussed in the introductory chapters.

Chapter 2

CURRICULUM THEMES

2.1 Introduction

Since the beginning of the Twentieth Century there has been an ongoing debate about the approach to be adopted in the teaching of biology. This debate is largely whether school level biology should be taught as the science of life emphasising biological knowledge or whether it should be a science of living, emphasising the personal needs of students and the general needs of society. Associated with this debate has been a changing emphasis among three primary aims - the knowledge aim, the methods aim and the personal/social aim.

In more recent years, and especially since the onset of the "discovery" or "inquiry" learning movement of the mid 1950s there have been attempts to resolve this issue through curriculum reform. In addition to general trends such as increased emphasis on problem solving and higher order mental skills rather than on rote learning, increased attention to practical work, more attention being given to the nature and processes of science and the increased use of discussion as a classroom and laboratory method, the past three decades have been characterized by a search for appropriate curriculum themes. There have been attempts to select curriculum structures and sequences which adequately address the needs of biology as a science and the needs of biology as a science of living emphasising personal and social aspects. There is no doubt that in this search the pendulum has swung away from classical scientific biology towards emphasising the practical value of biology for all citizens with a corresponding de-emphasis on the preparation of secondary school pupils for further studies in the discipline. There has been a much greater emphasis on preparation for life in a scientifically and technologically based society and for helping young people intelligently understand the contributions and limitations of biology while using its data to advance the welfare of society as a whole.

Various thematic approaches which have been central to this debate are outlined below. In each case issues remain unresolved and challenges remain.

2.2 The Curriculum Themes

Some twenty curriculum themes are listed below and brief comments are provided on their rationale and on the challenges they present for curriculum reform. By curriculum theme is not meant a topic within a course of studies but the dominant approach adopted by the course as a whole. Different thematic approaches of course may have different significance for certain categories of learners and for different levels of the secondary school and where appropriate some comment is provided on these aspects.

The themes covered in this section are listed in the box below.

Curriculum Themes for Secondary School Biology

(a) Taxonomy and Systematics
(b) Evolution - the "Type" Approach
(c) Form and Function
(d) Branches of Biology
(e) Levels of Organization
(f) Human Biology
(g) Processes of Life
(h) Environmental Principles
(i) Bioethics
(j) Science Processes
(k) Social Issues
(l) Science in Society
(m) Science and Technology
(n) Vocational Preparation
(o) Personal, Family and Quality of Life Development
(p) History, Philosophy and Sociology of Science
(q) Epistemology and the Psychology of Learning
(r) Economics and National Development
(s) International Education
(t) Sociobiology

(a) Taxonomy and Systematics

In most school systems of the world through until at least the early 1930s, biology was taught as botany and zoology. Frequently these subjects were treated descriptively and included lists of the main groups - phyla and usually classes in the case of zoology, and major taxa and especially common families of the flowering plants in the case of botany. For example the 1922 text book by E.W. MacBride Zoology the Study of Animal Life (1), while including a little on cells and tissues and on evolution consisted mainly of accounts of the characteristics of major animal groups from the Protozoa to the Chordata illustrated by brief reference to familiar examples.

Truly integrated biology teaching was not possible until this systematic approach was abandoned. So by the early 1930s most school systems turned to other curriculum patterns and the systematic approach fell into disrepute. In most cases taxonomy and systematics was reduced to only one topic of the curriculum generally giving a very broad view of diversity with some attention to how organisms are grouped and named, and on processes such as the elementary construction and use of taxonomic keys. Instead of representing the more than 90 percent of a typical biology programme of the 1930s systematic studies usually came to represent less than 10 percent of the content of courses in the 1970s and 1980s.

CHALLENGE: As natural environments continue to be degraded and more and more species become endangered, there is a race to identify and describe the millions of as yet undescribed organisms. This race is associated, too, with the growing realisation that DNA data banks can and should be established of all types of living things. These trends have returned systematic and taxonomic studies to centre stage. The challenge for biology education is to find ways to give more prominence to these fundamental aspects without distorting recent trends which stress issues of more direct social application.

EXEMPLAR CURRICULA

(i) CHINA: An interesting example of a classical systematic approach to biology syllabuses in Botany and Zoology: Middle School, Peoples Republic of China. (2)

(ii) AUSTRALIA: A minimalist approach is adopted by most secondary biology curricula in Australia. The main textbook Biological Science the Web of Life (3) has a chapter on "Kinds of Organisms", one descriptive chapter on each of plants, animals and micro organisms, and a twenty or so page appendix which catalogues living things by major groups, including at least the major families of the flowering plants, the main animal phyla and the key insect orders.

(iii) CANADA - BRITISH COLUMBIA: The course for secondary schools grade 11 in British Columbia (4) places diversity and functional aspects of micro organisms, plants and animals in a key position. These aspects form a compulsory core of 70 instructional hours. An additional 30 hours of optional electives makes up the balance of the course. Students may elect to study more diversity (up to 25 hours each in areas such as vertebrates or invertebrates and 5 hours on each of mycology or ferns) or innovative topics such as fisheries biology, wildlife biology, silviculture, bioethics, careers in biology or aquaculture.

(b) Evolution - the "Type" Approach

A variation of the "systematic" approach to the organization of the biology curriculum was to base a programme on the main groups of animals and plants with the teaching order organized as an evolutionary sequence from the most simple to the most complex. This approach was also characterized by the treatment of "types" or representative species which would be taught in some detail. For example a typical course in secondary school zoology in the 1920s and 1930s, might include in-depth studies of Amoeba, Obelia, the earthworm, snail, crayfish, grasshopper, starfish, fish, frog and rabbit.

Textbooks were frequently organized with a chapter on each phylum structured as a general account of the phylum, a description of one or more types and then an account of the taxonomy of the phylum (5). The emphasis was on structure, life cycles, classification and on evolutionary relationships (6). The central aim was to demonstrate the course of evolution and to vindicate the Darwinian interpretation of diversity.

The "type" approach was an extension of the views of T.H. Huxley who believed the detailed study of one organism, such as a crayfish, trained students in observation (7). Huxley also assumed that the general processes of life could be inferred from the study of one type and that transfer of knowledge would occur from the detailed understanding of one example to an understanding of the full range of diversity.

The Huxley model is seen by many modern taxonomists to be scientifically and educationally unsound. It stressed the memorization of detailed structures of limited and restricted applications. Further many of the generalizations which were supposed to follow from "type" studies could not in fact be made. Courses restricted to "types" could in fact be misleading and give a distorted and over simplified view of diversity. To demonstrate the course of evolution, therefore, tended to go out of favour in the 1940s to be replaced by a different "type" approach with a greater functional emphasis (see next section) with "types" being used for a different purpose - namely to demonstrate the link between form and function. Many courses came to be organized around the structure and function of a typical flowering plant or of the human body (8).

CHALLENGE: The strengths of the evolutionary "type" approach were (i) the stress on developing observational skills (ii) an appreciation of the wonder and complexity of living organisms (iii) a demonstration of evolution (iv) training in both inductive and deductive reasoning based on detailed observation and (v) a systematic approach to the study of living things. Today's challenge is to find ways of retaining these advantages and strengths without overloading school systems with detailed accounts of the structure, life cycle and classification of dozens of individual organisms. If a "type" approach is to be retained it should be highly selective and the "types" chosen for purposes other than their positions in a taxonomic hierarchy.

EXEMPLAR CURRICULA

(i) MALTA. In the biology course for form 3 in Malta, types are used throughout to illustrate both evolutionary sequence and other issues such as levels of organization, physiological processes, parasitic adaptations and principles of classification (9).

(ii) PAKISTAN. The syllabus for School Year IX specifies practical observation of types representative of each major plant and animal phylum. This "traditional" approach, however, is supported by more general functional topics and by studies of the environment (10).

(c) Form and Function

The earliest of courses of study in the biological sciences included an examination of the relationship between structures and their functions. Two aspects of this, however, have been given variable attention. The first is the proportion of a total programme to be devoted to this issue and the second is which proportion of a unit or units in this area should be given to "form" and which proportion to "function". In the first half of this century most attention was given to "form" - that is to structures, life cycles and classification. Functional aspects were frequently taught separately in specialized courses such as human physiology which gave minimum attention to anatomical (ie structural) aspects.

Form and function studies were still relatively unpopular in the 1940s and 1950s and it was not until the advent of the electron microscope in the 1960s and the discovery of ultrastructure that there was a re-examination of this approach to biology. The newly observed structures within cells demanded functional interpretation. New syllabuses and programmes began to emerge which focused especially on cellular structures and their functions, leading eventually to an almost all consuming interest in the genetic code, the genetical control of biochemical processes and eventually to biotechnology.

This trend tended to overshadow the more classical studies of the relationship between form and function and more general topics in this area tended to be omitted from many school programmes. Nevertheless some pioneers in this area perceived the dangers of neglecting the studies of the structure and functions of organisms as entire entities and of organ systems, organs, and tissues and advocated a more balanced approach. One such pioneer was Professor John A. Moore whose college textbook Principles of Zoology published in the USA in 1957 was a landmark in this area, particularly so because of its unusual focus on studies of form and function in embryological development (11).

More recently (December 1987) the American Society of Zoologists, strongly influenced by Moore's thinking, has produced a volume on this topic in its series "Science as a Way of Knowing". While this is mainly concerned with college level biology it has implications for school level programmes. While modern courses of school biology now give a more balanced approach to functional systems there are no courses which closely examine the relationships between form and function as their main conceptual basis or to the key to the programmes as a whole as advocated by the American Society of Zoologists. Such approaches are at present restricted to colleges and universities.

CHALLENGE: Since detailed studies of the relationships between form and function are usually highly complex it is unlikely that school level programmes would ever be totally structured around this approach. The challenge for biology educators, therefore, is to select suitable illustrative case studies for inclusion in more general programmes and to teach both structural and functional aspects of plant and animal organization in a more balanced way.

EXEMPLAR CURRICULUM

AUSTRALIA - NEW SOUTH WALES. An experimental programme for the Higher School Certificate Examination in Multi-Strand Science in the 1960s was strongly influenced by the thinking of John Moore. A text book was issued which stressed structural and functional relationships at the cellular level and in selected organ systems - using the nervous system as a detailed case study (12).

(d) Branches of Biology

Among the discipline-oriented approaches to the structuring of the biology curriculum the use of the classical "branches" of biology has had only limited currency. By "branches" is meant not the "types" of biology such as microbiology, botany, zoology, agriculture and so on, but the subdisciplines such as taxonomy, anatomy, cytology, histology, physiology, embryology, evolution, behaviour, ecology and genetics. Frequently cytology, histology, physiology, embryology and anatomy are synthesised in studies of whole "organism" biology while separate units are provided in evolution, ecology and genetics.

Whatever the combination of the subdisciplines, an approach based on their scope and interrelationships reflects an academic approach and is usually intended to provide the basis for further studies. There is no room in such an approach for major units on societal issues although specific examples of social applications can be introduced at relevant points.

At college level semester courses can be provided on the various branches but in school biology a more holistic approach is required. Nevertheless school level programmes should somehow explain the scope of the various subdisciplines and give some understanding of their specific methods of inquiry.

CHALLENGE: A major challenge for curriculum designers is to develop school level curricula which are not merely structured around the subdisciplines but which introduce learners to their scope, interrelationships and methodologies by means of a more integrated approach. This is usually achieved by introducing the "branches" through holistic studies of individual organisms, complemented by studies of populations.

EXEMPLAR CURRICULA

(i) CUBA. The biology course for secondary schools in Cuba is structured around the classical branches of biology: cytology; anatomy; physiology; embryology; ecology; genetics; systematics; evolution; and conservation. An interesting aspect is that a supplementary unit is added on biological aspects of politics and moral behaviour (13).

(ii) NIGERIA. The Biology Curriculum for Senior Secondary Schools is structured around units of classification, cytology, physiology, ecology, evolution and genetics. While the majority of the course focuses on physiological processes in both plants and animals the various subdisciplines are clearly demarcated (14).

(iii) SOVIET UNION. In the Soviet Union there is an interesting combination of a systematic approach combined with a treatment of "branches". Different approaches are applied at different grades with taxonomic studies of the plant and animal kingdom predominating in school grades VI, VII and VIII, human biology in grade IX and ecology, physiology, evolution, molecular biology, genetics and biotechnology in grades X and XI (15).

(e) Levels of Organization

An especially influential approach to biology curriculum design has been to structure content according to levels of biological organisation - the chemical (subcellular level); the organ, organ system and whole organism levels and the population level. The well known Biological Sciences Curriculum Study (BSCS) established in the United States of America in 1958 initiated this approach with the publication in 1963 of three famous textbooks Biological Science: A Molecular Approach (originally Biological Science: Molecules to Man) (blue version), Biological Science: An Ecological Approach (green version) and Biological Science: An Inquiry into Life (yellow version) (16), the yellow version emphasising whole organism and organ system biology. These three books were intended as alternative approaches or "models" for the curriculum. Actually while some school systems chose one or other of the approaches many appreciated that all three models could be combined into a conceptual structure which provided a useful way of viewing the structure of biology as a whole. Many programmes, therefore, introduced the concept of "levels" as the main unifying theme for their overall approach.

CHALLENGE: The "levels" approach of course reflects a "scientists" view of biology and therefore it conserves the inherent structure of the discipline as the main curriculum theme. Nevertheless it is highly innovative compared with the earlier attempts to structure programmes around systematics, evolution, form and function or branches of biology. It makes it easier to compare and contrast the techniques of science which operate at the various levels and it provides a useful coherent framework for investigating philosophical aspects such as the classical reductionism versus organicism debate. The challenge for contemporary science curriculum developers is to stress these useful and important organizational, methodological and philosophical aspects of the "levels" approach within the broader context of a socially oriented biology.

EXEMPLAR CURRICULA

(i) HONG KONG. The programme for Advanced Level biology in Hong Kong is structured around five sections: (1) Variety of Living Organisms (2) the Cell - arranged in a sequence from chemical components, subcellular structures and cell functions (3) the Functioning of Living Organisms - the organ systems of both plants and animals (4) Genetics and Evolution and (5) Inter-Relationships of organisms with each other and with their Environment. The emphasis is on sequential levels of complexity (17).

(ii) UNITED KINGDOM - LONDON A-LEVEL GCE. The syllabus for the Advanced Level of the General Certificate of Education of the University of London has an introductory section entitled "Levels of Organization"; a series of units on whole organism biology (eg. metabolism, exchange and transport and so on) and a final unit entitled "Population Biology and Ecology". This syllabus makes the "levels" approach strongly overt (18).

(f) Human Biology

Several school systems have introduced programmes of human biology, usually offered as alternative electives to more conventional biology courses. These programmes have frequently grown out of the older style human physiology courses and have been strongly influenced by the "type" approach with Homo sapiens as the exemplary "type". While the best of these courses have implications for general education many have a vocational bias and are popular with senior school pupils planning future careers in medicine, and in nursing or other paramedical professions.

More recent courses in human biology not only deal with physiological aspects of the human body but also include topics such as humankind and biodiversity; humans and the environment; human populations; human evolution; the biological basis of race; behaviour; human biogeography and international relations; and bioethical aspects of the human condition. The approach tends to minimize a treatment of plant biology but is generally popular with those enrolled because of the self referencing focus.

CHALLENGE: The main danger of the human biology approach is its relatively narrow focus and care must be taken to include broader topics relating to populations, the environment and bioethical matters. Some attention needs to be given to biodiversity, possibly approached from the viewpoint of examining humankind's responsibilities in regard to other forms of life. The major challenge is to prevent human biology from just being a revamped programme of classical human physiology. An especially important aspect is for curriculum workers to see the special opportunities provided by human biology for considering bioethical and other philosophical issues.

EXEMPLAR CURRICULA

(i) CANADA - QUEBEC. The senior secondary course in Human Biology in Quebec is an optional alternative to a more general programme in biology. While this course is essentially a programme in basic human physiology and hygiene it does include many issues of social relevance such as sex education and a treatment of sexually transmitted disease (19).

(ii) UNITED KINGDOM - MIDLAND EXAMINING GROUP. The Midlands Examination Group's programme in Human Biology for the UK General Certificate of Secondary Education was examined for the first time in the summer of 1988. While it is essentially a programme of human physiology and hygiene it places such studies in the context of animal diversity ("Man's Place in the Animal Kingdom") and the human environment including "relationship with other organisms" (20).

(g) Processes of Life

By "processes of life" is meant the major functional systems such as metabolism, responsiveness and control, respiration and energy relationships, movement, reproduction, transport, excretion and so on. In courses organized in this way a comparative approach is usually adopted, with similarities and differences between plant and animal systems being stressed and examples being chosen from various taxonomic groups. This approach is probably the most popular way of structuring modern school biology programmes, and the majority of school courses at present tend to be organized in this way. There is usually a reduction in the amount of structural detail provided and technical terminology is kept to a minimum. The approach is "discipline" oriented as it examines how different types of organisms function in terms of life processes.

CHALLENGE: The danger of this approach is that the treatment can become too detailed. If too many examples are given and if the treatment is exhaustive, the programme becomes very academic and largely divorced from concerns and interests in the daily lives of pupils. The challenge, therefore, is to introduce life processes in the broader context of living in the complex modern world, linking them to issues of the day such as population and family planning, health, economic development and quality of life. This can be achieved if life processes are treated only very broadly.

EXEMPLAR CURRICULA

(i) SUDAN: The three year programme of secondary biology in the Sudan is totally structured around the processes of life dealing with topics such as adaptation, protection, movement, nutrition, internal transport, respiration, excretion, growth and reproduction. The main focus is on humankind and on the flowering plant but comparative examples are introduced where appropriate (eg. fungi, algae, earthworm, insects etc.) (21).

(ii) UNITED KINGDOM - NUFFIELD ORDINARY LEVEL GCE: This five year programme deals with an introduction to living things in Year I and in the subsequent years adopts a "processes" approach: Year II "Life and Living Processes"; Year III "the Maintenance of Life"; Year IV "Living Things in Action" and Year V "The Perpetuation of Life". A comparative approach is adopted and systems are dealt with in minimum detail; an inquiry methodology is advocated throughout and wherever appropriate applications to everyday life are indicated (22).

(h) Environmental Principles

While almost all modern school level biology courses deal in some way with environmental issues few have structured whole programmes around the environment as a dominant theme. While the "environmental education" movement is very active and influential it has tended to advocate the introduction of environmental concepts into existing more conventional biology courses and also into other subjects, especially geography, language and literature studies, the arts, technology subjects and so on. The argument has been that the overcrowded "subject" oriented school curriculum cannot find room for a new subject wholly devoted to the environment - vitally important as that may be. Also it is stressed that environmental issues are not "subject" bound and are truly holistic and hence interdisciplinary.

Nevertheless a few school systems have developed school level biology programmes largely based on environmental issues as their central theme. These have tended to be in countries with particular environmental interests and concerns.

CHALLENGE: The central challenge for the biology educator is to introduce environmental issues throughout the programme rather than limiting them to a single unit usually entitled "Ecology and the Environment". The biologist also can work in other curriculum areas to assist in the growth of an interdisciplinary approach.

EXEMPLAR CURRICULA

(i) AUSTRIA. Austrian education has been influenced by the OECD Project "Environment and School Education" and has adopted an interdisciplinary approach to the introduction of environmental concepts. The biology course for the 5th to 8th grades of the compulsory and academic secondary schools is entitled "Biology and Environmental Science" and places a strong emphasis on environmental issues (23).

(ii) ICELAND. The Icelandic Secondary School biology curriculum focuses on the environment, especially, as one might expect, on aspects of marine biology, and the dangers of marine pollution, overfishing and of general misuse of the sea are of central concern. The course, therefore, stresses an understanding of the ecosystem of the oceans (24).

(i) Bioethics

Bioethical issues are now receiving greater attention in school biology courses than in any time previously. A recent world survey by the Biology Education Commission of the International Union of Biological Sciences (IUBS-CBE) suggested, however, that as yet school curricula have not introduced bioethical ideas as a predominant theme for structuring a total programme (25). While obvious ethical issues arise from studies of new technologies associated with human reproduction, the environment and biotechnology, there are ethical aspects of almost all aspects of biology - behaviour, blood transfusion, evolution, drug abuse, animal experimentation, use of food additives and misuse of energy immediately come to mind as obvious examples.

Studies of bioethics, therefore, will almost certainly become major themes in future biology curricula. Part of the reason for this is that general educators have become more aware of the importance of values clarification in school programmes as a whole. While most attention has been given so far to values in the social sciences, issues involving values and ethics are now being introduced into the sciences. Biology, with its emphasis on life and of the place of humankind in nature, is an especially useful vehicle for conveying these important societal messages.

CHALLENGE: As the general community becomes more aware of and concerned about bioethical issues in daily affairs, so curriculum designers are challenged to introduce aspects of bioethics into school biology programmes. At present several curricula include units on bioethics (eg. the Biological Curriculum Study in the USA and elective options in the biology courses for Years 11 and 12 in British Columbia - see notes 16 and 4 respectively), but as yet the bioethical theme has not been used as the total framework for any secondary school biology programme. The main challenge is to ensure that bioethical issues are dealt with throughout a course and not just as isolated topics.

EXEMPLAR CURRICULUM

IUBS-CBE. While no school system has yet developed a total programme of secondary school biology based on bioethics as the central theme, the Education Commission of the International Union of Biological Sciences (IUBS-CBE) has prepared guidelines for the development of such a course. A statement of aims has been published and topics in a conventional biology course which could be illustrated by bioethical examples have been identified (26).

(j) Science Processes

The inquiry or discovery learning approach adopted by many science curricula in the 1950s including the BSCS courses in the United States (see note 16) and later the Nuffield Programme in Britain (see note 22) have been very influential in focusing attention on science as "process" rather than "product" alone. An attempt was made in these types of courses to introduce scientific concepts through problem solving and to introduce, through guided discovery, a flavour of the excitement of science as a pursuit of new knowledge. In the 1960s a brave attempt was made in the United States, largely on the initiative of the American Association for the Advancement of Science (AAAS), to structure a totally integrated science programme around the processes of science. This, rather surprisingly, was intended for the first years of the elementary school (K-3) and was published under the title Science - A Process Approach (27). The "processes" identified in this programme included: observing; classifying; measuring; using space/time relationships; using numbers; communicating; inferring and predicting. Since the 1960s most secondary school biology syllabuses have introduced a "process" oriented approach but have built this into the methodologies of teaching rather than as the main structural theme of the courses as a whole.

In more recent years there has been a reassessment of the place of inquiry learning and "process" in school science curricula. Science educators are coming to see these as elements of the broader issue of scientific literacy (28). The IUBS-CBE is at present

(1991) developing guidelines for curriculum reform in biology which focuses on improving the levels of biological literacy in the community at large (29).

EXEMPLAR CURRICULA

(i) CANADA - ALBERTA. The Biology course for secondary school grade 7 is built around a defined series of investigative "process" skills and subject matter topics have been especially selected to make it possible to most readily develop these skills. These topics are grouped into three categories: (i) classification (ii) fundamental biological processes and (iii) interdependence. The "process" skills are identified as: observing with all the senses; classifying related objects or ideas; quantifying measured data; manipulating data to identify the patterns; identifying problems clearly so that the variables may be controlled or manipulated; interpreting data; making inferences leading to hypotheses and predicting future behaviour (30).

(ii) USA - KENTUCKY. In the biology course for the tenth grade of Kentucky schools "branches" of biology, namely inquiry; cell biology; genetics; human biology; diversity; evolution and ecology provide the content framework (31). An interesting aspect, however, is that the Department of Education issues a statement about science skills which are to be developed in all science programmes (32). For science subjects grades 7-10 (including biology) the following process skills are defined and recommended teaching procedures are carefully described:

Observing
Classifying
Inferring
Predicting
Measuring
Communicating

Interpreting Data
Making Operational Definitions
Formulating Questions and Hypotheses
Experimenting
Formulating Models

(k) Social Issues

The "science and society" movement which had its origins in the 1970s began to influence biology curricula in the 1980s, but nevertheless is less evident today in biology courses as such as in programmes of general or integrated science. There are two aspects of this movement. The first is to begin with the science showing how scientific principles are functionally applied in our modern technologically based society, and the second is to begin with sensitive social issues and showing how many of these have emerged because of scientific discoveries or applications (33).

The applied science approach frequently focuses on technology but there are some programmes such as the Science and Society programme in Britain with a broader focus (see exemplar below). The "issues" approach focuses mainly on social decision making. Professor Peter Kelly distinguishes between scientifically oriented studies and studies of social decision making by labelling them "Knowledge Studies" and "Issues Studies" (34). Kelly proposes a framework as a guide to action in developing curricula based on these two approaches. This framework is given below.

Knowledge Studies	Issue Studies
. Emphasis on knowing and understanding	Emphasis on problem solving and decision-making
. Unknowns tend to be known	Unknowns not necessarily known
. Reflective	Motivation derived from social and/or individual action.
. Low moral load	High moral load
. Precise terminology	Confused terminology
. Unitary integration	Eclectic integration
. Mainly invariable, possible hierarchical, arrangement of concepts	Variable arrangement of concepts

Margaret Brumby has discussed in some detail the definition of an "issue" and has identified, described and discussed a range of biologically based issues suitable for treatment in school programmes (35). Many examples are related to the human condition and have medical applications. Most have strong bioethical overtones.

CHALLENGE: A programme treating only social issues would be essentially a course in social science. In a biology programme a fine balance has to be maintained between knowledge studies and issue studies. A further challenge is to present "issues" as social problems and to apply and develop problem-solving skills in their resolution. This becomes an "extension" of the inquiry approach applying it to the science-societal interface. In the case of the type of science and society programme which focuses more on applied science the challenge is to show the relationship between the basic science and its application without overloading the examples with too much technological detail.

EXEMPLAR CURRICULA

(i) UNITED KINGDOM - NORTHERN EXAMINING ASSOCIATION - BIOLOGY (HUMAN AND SOCIAL). This syllabus issued for the General Certificate of Secondary Education in Human and Social Biology is essentially a course in human physiology and hygiene but the social implications of all topics are strongly emphasised eg. maintaining healthy ecosystems; development of alternative food sources; food hygiene; treatment of waste; public health and immunization (36).

(ii) UNITED KINGDOM - SCIENCE IN SOCIETY for the AO LEVEL EXAMINATION - Oxford and Cambridge Schools Examination Board. While this is a course of general science rather than biology it includes many topics of biological concern. It is designed for 16 year old pupils and has a strong applied focus. Topics include: disease and the society; population and health; medicine and care; food; agriculture; energy; mineral resources; the nature of science; science and social development; looking to the future; defence and energy issues and a series of units on specific aspects of industry (37).

(1) Science in Society

A science IN society theme differs from the social issues theme. The latter is concerned with an analysis of the scientific aspects of social issues whereas a science in society approach examines the nature of science itself as a social enterprise. It generally deals with issues such as science as a social phenomenon, the economics of science, the characteristics of the scientific community and the determination of science policy.

So far very few school level biology courses have been totally structured around this approach but issues relevant to the nature and place of science in society are receiving increasing attention as units of work within programmes. This type of approach is having an increasing impact and several more recent school programmes, while retaining more traditional thematic structures as their general framework, require these types of issues to be dealt with as a continuing underlying thread throughout the courses as a whole.

CHALLENGE: As the scientific community becomes increasingly accountable to a better educated and informed general community so the myths of the objectivity of science and of science as being "value" free have been rejected. It is now appreciated that since science is a product of humankind it is socially determined and that all informed citizens in a democracy should have a say in influencing science policy. The challenge for the biology curriculum designer is to present school level courses in such a way as to make these types of issues overt. This aim is linked to the skills associated with scientific literacy, problem solving and decision making and should focus on giving pupils an appreciation of their role as future members of a democracy in regard to science based policy issues.

EXEMPLAR CURRICULUM

USA - IDAHO. While the framework for the Grade Ten biology syllabus in Idaho is based on the "processes of life" approach the course is designed with "science as a social phenomenon" as a continuing underlying theme. The course examines: (i) science as a way of knowing emphasising the nature of scientific explanation and contrasting it with other forms of knowledge; (ii) the role of science in solving personal and social problems interfacing with biology and (iii) science as a part of culture. In particular, stress is placed on aesthetic as well as practical aspects of science, on the influence of science on economic development, on the impact of science on government policy and vice versa, on the impact of science on science development, on the role and impact of science in relation to art and literature and in relation to culture in general. This is a most innovative and forward looking programme (38).

(m) Science and Technology

Technology is the scientific study of industrial and mechanical arts (39), and modern biology can contribute a great deal to technologically based development. Increasing attention is now being given to technological aspects of biology. For example Edward Rugumayo has argued that "Energy" is a useful unifying concept for the development of biology curricula, especially in the area of ecology (40). "Energy" as a unifying theme has also been reviewed by Michael Tribe and Alan Pritchard (41). Biotechnology, once the province of advanced research laboratories in developed countries, is now making a major impact on crop yields and on medical developments in the third world and this has significant implications for its place in school biology courses (42). Examples of appropriate biotechnological topics and issues for inclusion in school level biology courses have been reviewed by William Padolina, especially as they apply to developing countries (43). IUBS-CBE has also drawn attention to the importance of including biotechnology in school courses (44) and world surveys have been undertaken to determine the extent to which this and other technological aspects have been introduced into school level curricula (45). Alan Pritchard has indicated that technological aspects of biology can be introduced in the teaching of agriculture, biotechnology, biogas studies, dairy biotechnology, medical technology and conservation studies (46).

In spite of this increased interest in technological aspects, few school biology curricula are structured around technology as the major unifying theme. There are of course many school level courses in agriculture, and many of these are strongly technological in orientation (47). Technological topics are, however, frequently included as units of study or as optimal electives in main stream biology courses.

CHALLENGE: Some technological aspects of biology are complex and could present some difficulties for students, especially in the field of biotechnology. Nevertheless the rapid growth of biological based technologies must be reflected as strongly as possible in school level biology courses. The challenge is to select appropriate examples and to treat them at a level appropriate for the majority of learners. While it may be unrealistic to structure a complete programme around technological aspects, at least appropriate examples should be introduced throughout all areas of the programme.

EXEMPLAR CURRICULA

(i) PHILIPPINES. A new four year secondary science programme began in the Philippines in June 1989 under the title "Science and Technology" with biology being taught in secondary year two (Science and Technology II - Biology). As the name suggests this biology programme gives major emphasis to technological aspects. There are units on technological aspects of health and there is a major unit on biotechnology. The approach is inquiry oriented and pupils are encouraged to apply biological principles in making decisions and solving problems in family life; agriculture; management of resources and in improving the quality of life (48).

(ii) DENMARK. The 1988 programme in biology for the three years of senior secondary school (the Gymnasium) for ages 16+ is heavily technological in orientation. Technological themes are linked to the various branches of biology as shown below:

Themes:	Disciplines:
Biology as science	Genetics and evolution
Biological production and biotechnology	Physiology
	Ecology
Health and diseases	Biochemistry
Nature and environment	Microbiology

The "discipline" of ecology within the programme, for example, relates technological applications to ecological concepts in the following way.

Biology as science:	Population biology
Biological production and biotechnology:	Agriculture Aqua culture
Health and diseases:	Pollution of drinking water Bioaccumulation
Nature and environment:	Natural resources management

The course emphasises social issues and in particular stresses the impact of biologically based technologies on nature, society and humankind. An inquiry problem-solving approach is advocated (49).

(n) Vocational Preparation

Apart from their general educational role, school level biology courses may have an academic orientation, preparing students for further studies in biology, or alternatively may have a more general vocational orientation. Applied courses in school level agriculture are obvious examples of vocational emphasis, as are many technologically orientated programmes of the types discussed in the previous section (section m). Structuring an entire school level biology course around general vocational preparation, however, is relatively uncommon. Where school programmes have this orientation the main science vehicle is usually a programme of general or integrated science.

There is a growing appreciation among curriculum designers, however, that recent advances in biology have direct vocational implications in career areas such as health and medicine; para-medical professions; biotechnology; agriculture; wildlife management; environmental management; resource management and so on. Career oriented courses, therefore, are beginning to be organized for school grades 7 to 10 and for the grades of the senior school.

CHALLENGE: Because of the increasing number of biologically based careers that are now available, school level biology should have at least some vocational orientation. There are two aspects to this. In the first place those areas of biology which have career relevance may need to be highlighted. In the second place courses should at least heighten awareness about the types of careers that are available and give some account of their scope and educational requirements. This is of particular significance for pupils about to leave school.

EXEMPLAR CURRICULUM

ZIMBABWE - UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE INTERNATIONAL EXAMINATIONS SCIENCE (ZIMBABWE) (5006 and 5007). While these are General Science courses, they have strong biological components. Course 5006 is for the ordinary level of the Zimbabwe General Certificate of Education. Course 5007 is an optional extension for students who wish to study some science after the O-Level Examination. Both courses assume knowledge of the Zimbabwe Junior Certificate syllabus in science. The courses emphasise practical applications of science in (i) agriculture (ii) industry (iii) energy uses (iv) structures and mechanical systems and (v) the community in general. Central aims include an appreciation of the impact of science in the work place and of its influence on social, economic, industrial, health and quality of life issues. There is a clear vocational orientation in that there is a practical analysis of the current applications of science and technology in Zimbabwe (50).

(o) Personal, Family and Quality of Life Development

The complexities of modern society have placed individuals, families and indeed entire communities under increased pressures. School programmes have responded by introducing courses in personal development, family life education and quality of life improvement. Many of these have been either extra curricular or interdisciplinary. Biology, however, as a science of life, if treated sufficiently broadly, can accommodate many aspects of these themes. In more recent years, therefore, secondary school biology courses have given greater attention to these significant issues and a few have tended to be predominantly structured around them.

By "personal development" is meant mainly psychological development. Since the popular publication by Sheehy of Passages: Predictable Crises of Adult Life in 1976, there has been an upsurge of interest in life-line planning (51). It is not surprising of course that the main impact has been in continuing education and higher education (52), but at secondary school level some attention is being given to helping pupils cope with their present stage of life and to prepare for career training and becoming established as young adults. Issues such as self identity and self esteem are seen to be especially important. Health education and physical education (53) are of course components of this, but personal development programmes are mainly concerned with facilitating balanced physical and psychological growth.

By family life education is meant an examination of the nature of the family, family roles and responsibilities, family planning, economics and budgeting issues in the family, parenting and the family's place in society. This area is of special importance in turbulent modern society where in developed countries, the nuclear family is under threat, and where, in the third world, the sociology of the extended family is undergoing rapid change (54).

By quality of life education is meant programmes which "aim to equip the community with that essential social knowledge, attitudes, values and skills about problems and issues affecting society as a whole so as to improve the life styles and standards of all citizens" (55). Issues usually dealt with in this area include population education, drugs, citizenship, social and cultural awareness and leadership. Most of these issues clearly have a strong basis in biology.

CHALLENGE: Personal, family and quality of life programmes are now becoming central to many school courses, especially at the secondary school level. In particular they aim at those pupils about to leave school. Biology provides a very suitable framework for the introduction and development of many of the concepts in these areas. The challenge is to introduce as many as possible of these ideas without losing the essential scientific base of biology by converting the subject into what could, without due care, become purely a social science.

EXEMPLAR CURRICULA

(i) MALAGASY. The Biology programme for the first cycle of the secondary school (school years 6-9) is structured almost entirely around individual and family and on improvement in the quality of life. Health issues are dealt with. Studies of human reproduction include a consideration of family planning issues. There is an extended treatment of family life including roles and relationships within the family, and the social life and responsibilities of the family. A unit is available on work and leisure and there is an extended treatment of agriculture as an exemplar. Quality of life is studied through conservation and also more directly in terms of mental and physical wellbeing, moral behaviour and personal and national development (56).

(ii) JAMAICA. Since 1986 the Ministry of Education in Jamaica has promoted an interdisciplinary programme of family life education for the primary and secondary schools. It is intended that relevant family oriented topics be introduced into almost all subjects of the curriculum. Biology is seen to be especially relevant in this regard. Topics to be covered at all levels include family relationships, self identity, self esteem, safety, health, communications and social skills. At the secondary school level the following topics are to be treated: body parts and their functions; health care, physical and mental care; communication; adolescent/teenage problems; peer pressure - how to cope; drug abuse; sexually transmitted diseases; physiological/psychological changes - how to cope; generation gap; population dynamics; population - overpopulation; implications for development; Jamaica and overpopulation and contraceptive education (57).

(p) History, Philosophy and Sociology of Science

While these aspects have obvious links with the science processes and science and society themes treated above (section 2.2 (j) and (l)) they can be treated separately from those themes because of their greater focus on the nature of science itself. Historical examples have been frequently introduced into many school curricula and textbooks - especially those largely based on the "systematics", "form and function", "branches of biology", "human biology" and "processes of life" approaches. (See relevant sections above.) These examples, however, have usually been to describe the origins of specific ideas (eg. Hooke and cells, Harvey and circulation, Watson and DNA and so on) rather than as case studies of the evolving nature of science itself (58). In fact the simplistic approach usually adopted has tended to give a false impression about how science has emerged in its present form from its early origins in mysticism and superstition (59).

The philosophy of science is even more neglected or poorly taught at school level and fundamental issues such as the nature of scientific explanation and scientific thinking are rarely examined. Recent books such as Chalmers' What is This Thing Called Science? (60) have provided educators with useful guidelines for treating basic philosophical issues in science programmes and there has been considerable attention paid to this issue in the science education literature (61). But so far the impact at school level has been minimal.

The sociology of the scientific community has been especially badly neglected in all branches of science at school level. Books such as Stuart Blume's Towards a Political Sociology of Science (62) and the works of Thomas Kuhn (63), Karl Popper (64), Barry Barnes (65), M.J. Mulkay (66) and others have established frameworks for these types of studies but have made very little impact on school science curricula.

The current neglect of a self analytical approach to science in science courses at school through appropriate historical, philosophical and sociological studies is partly explained by the relatively recent emergence of such studies at the levels of research and advanced scholarship and also by the fact that usually such studies are relatively complex. These areas cannot, however, continue to remain outside the province of school science - especially biological science. This is partly because science is being held more and more to account for its impact on society and it is imperative that all citizens have some understanding of the nature of the scientific enterprise and the characteristics of the scientific community.

CHALLENGE: The challenge for biology curriculum designers is to analyse the essential current thinking about the nature of science as revealed by relevant historical, philosophical and sociological studies and to codify and simplify these ideas for integration into school level courses. The aim should be to reveal the tentative and speculative nature of scientific explanation and to give insights about the nature of science as a social product. This is an important aim. As the general public inevitably becomes more involved in making decisions about scientific matters - aspects of biotechnology, nuclear energy, mental health therapy, space exploration, star wars and so on - so must they possess the means of analysing the merits of each case and especially the merits of rival claimants. If the public understands a little of the complex social factors which interact to define the boundaries of knowledge they will be less likely to accept the rhetoric of rival groups at face value. They will be more on guard against the misuse of knowledge and will be better able to identify vested interest, bias, prejudice and special pleading.

EXEMPLAR CURRICULA

(i) USA - IDAHO. The Grade Ten Syllabus in Biology in the State of Idaho has been described above in section 2.2 (1) as an exemplar of the "science in society" theme. This programme also involves an examination of the nature of scientific knowledge and of scientific explanation and is one of the few examples of such an approach at school level. As examples from this programme two of the relevant goals and their related objectives are reproduced below:

A. Goal:

Students will explain what it is to know something scientifically and be able to contrast scientific knowledge with other kinds of knowledge.

Objectives:

Students will:

1. Define observation.
2. Explain the role of verification in science.
3. Distinguish between fact and opinion.
4. Distinguish between observation and inference.
5. Explain that scientific knowledge is based upon human interpretation of observable facts.
6. Identify other sources of knowledge and explain how such knowledge differs from scientific knowledge.

B. Goal:

Students will define science as a human enterprise and understand that all scientific knowledge is tentative and subject to critical review and revision.

Objectives:

Students will:

1. Explain that scientific knowledge is based upon human interpretation of observable facts.
2. Cite examples of change in our understanding of biological phenomena.

3. Develop criteria for evaluating the validity of biological knowledge.
4. Pose alternative interpretations of observation of biological objects or events.
5. Pose alternative hypotheses to account for observations. (67).

(ii) UNITED KINGDOM - ENGLAND AND WALES. SCIENCE IN THE NATIONAL CURRICULUM. In England and Wales a national curriculum in science for the ten compulsory years of schooling will be introduced for the first time under legislation passed in March 1989. This is a general science programme but it contains a strong element of biology. Throughout the programme there is a strong emphasis on an exploration of the nature of science. There are two key units entitled respectively "Exploration of Science" and "The Nature of Science" and these are to be taught in all ten grades. They emphasise historical and philosophical aspects of science and examine the nature of scientific explanation - for example how the nature of scientific explanation may differ from time to time or from culture to culture (68).

(q) Epistemology and the Psychology of Learning

Since at least the 1960s educators have been increasingly concerned about the effective selection and use of knowledge in school curricula and about how pupils learn (69). In the 1970s much of this thinking was applied to the analysis of secondary school science courses, especially biology (70). It was argued that biology programmes should be structured around functional knowledge as a tool and that the knowledge itself should be reduced to a minimum core of essential concepts which reflect reality. The aim would then be to organize the concepts and subconcepts for maximum learning and to show pupils how to organize and apply the vast bulk of more general knowledge now available. In more recent years this approach has been facilitated by the ready availability of low cost personal computers for the organization and retrieval of knowledge (71).

This aim has to an extent been reflected in most modern school level biology programmes through (i) a reduction in detailed information (ii) the selection of information relevant to the lives of pupils and (iii) the logical arrangement of the information in learning sequences. In most cases, however, these principles have been applied unsystematically and it cannot be said that many courses, if any, truly reflect the nature of knowledge and its applications or contemporary theories of learning.

CHALLENGE: As the knowledge explosion continues, especially in a dynamic subject such as biology, curriculum workers need to be more aware of the nature and use of knowledge itself. This knowledge needs to be reflected more strongly in the structure of school biology programmes.

EXEMPLAR CURRICULUM

IUBS-CBE - Andre GIORDAN "PRELIMINARY FOR A SYLLABUS IN BIOLOGY". While many modern courses in biology reflect the trends outlined above none has put forward a comprehensive epistemological and psychological rationale for structuring the programme. In 1988 IUBS-CBE suggested such a rationale. This emphasised that knowledge should be defined as a tool and topics selected appropriately; that the knowledge should be backed by appropriate scientific attitudes and that it should be organized around a series of primordial or basic concepts. The basic concepts were identified as metabolism, differentiation, self-reproduction, adaptation, regulation, information, identity, memory and evolution. Epistemological arguments for the selection, arrangement and application of those concepts were advanced (72).

(r) **Economics and National Development**

Development planners, societal decision makers, politicians and other national leaders are now realizing that material economic development alone is not enough to ensure sustained and sustainable overall national development (73). Material development must be accompanied by human resource development and the driving engine for human resource development is education. It can be argued (74) that education leads to improved attitudes and skills and hence to improved behaviour in the community at large and so to improved quality of work, higher incomes and still more positive attitudes. These in turn ensure a spiral of continuing development through high productivity, high income, high saving, high investment, an improved socio-economy, a reinforced good attitude, still higher productivity, still higher income and so on. This type of continued development achieves and also builds happy and prosperous families enjoying a sustainable environment, happy community relations and goodwill, healthy physical, mental and spiritual lives, a sound economy and a future orientation with clear direction and farsightedness (75).

In spite of this growing realization it is only the nonformal, adult and continuing education sectors which have focused on these issues as a framework for curriculum development (76). School level programmes have largely ignored these aspects and this is particularly so in the case of the natural sciences. In our modern technologically based society this seems to be inappropriate. Biology in particular with its newer range of technologies, its focus on environmental issues, its ability to foster personal and family development and so on, is an especially suitable subject for examining science-based aspects of economic and national development.

CHALLENGE: Biologists are not necessarily economists or development planners, but nevertheless those responsible for school biology curricula should have sufficient grasp of these areas to develop courses which will contribute directly to human resource development and hence overall economic development. Courses with a vocational emphasis (section 2.2 (n) go some way towards this but do not address a broad range of development issues. What is needed are some courses which link biological studies directly to national goals and aspirations and which highlight those aspects which will contribute to the achievement of those goals. An approach advocated by I.D. Zverev, goes some way towards this (77).

EXEMPLAR CURRICULUM

AUSTRALIA - TOWARDS A NATIONAL SCIENCE STATEMENT. In Australia all six states and the various territories have their own science programmes and most are based on the thinking of the 1950s and 1960s. At present there is a project to reassess the role of natural science subjects in the curriculum, sponsored by the Commonwealth Government's Curriculum Development Centre. A discussion paper on this matter issued by the Centre in 1988 comments as follows: "Ultimately, political decision-making depends on the general level of awareness and concern in society. If it is high enough we can choose the technology we get, and exercise some control over its social and economic effects. New developments in science often have implications for government policy. And, almost all public policy issues have scientific and technological implications" (78). Should these sentiments be finally translated into action, Australia may well develop new biology programmes which do focus on economics and national development.

(s) International Education

If humankind is to survive we must cooperate in the sustainable development of this increasingly overcrowded and overexploited planet. Fortunately the educational community is increasingly aware of its responsibility in this regard and programmes of international education at school level are beginning to emerge. Many of these are in the areas of social science but there is also the beginnings of interest within natural science programmes. The origins of this interest in part stem back to the human ecology movement of the 1960s when authors such as Paul and Anne Ehrlich challenged the world with dangers of the population explosion, the problems of managing non-renewable and renewable resources, pollution issues and the disruption of ecological systems (79). Their treatment was on a global scale and pleaded for international action. Educators have since applied these ideas to school courses (80).

The approach to international education can be broadened from human ecology alone to issues of more general significance including global economic planning, the relationships between the developed world and the Third World, geopolitical analysis, peace studies and global communications. John Becker and the Charles F. Kettering Foundation (among others) in the United States have been especially active in promoting this broader approach (81). It is true that if applied to the teaching of biology the approach would shift the emphasis very strongly towards the social aspects of biology and would tend to treat the subject more as a social rather than a natural science. This is probably the reason why at secondary school level, biology courses as such have not been totally structured around such broad international studies - but nevertheless biology courses do provide a suitable framework for such an approach. Their core of concern for human relationships, their focus on the environment and the scientific processes and life processes with which they deal, all provide a strong baseline for the issues of peace studies, resource management and so on which are characteristic of the broader approach.

CHALLENGE: If school biology can contribute in any way to greater international understanding, moderation of world problems and to improving global human welfare, there is absolutely no doubt it should do so. It should do so even at the sacrifice of its integrity as a purely scientific discipline by taking on some characteristics of a social science. Professor Peter Kelly points out that "with biological problems such as those of health, environment and population being fundamental to social development and, indeed, to personal survival, the need to foster an international perspective in the biological thinking of future biologists and laymen alike becomes imperative. However, it cannot be taken for granted" (82). He suggests that there are three dimensions to biological internationalism. These are that (i) biological principles are universal (ii) biology as a science is international and (iii) biological problems are international. He argues that "a biology course should contain conscious reference to each of these three dimensions and they could form the framework of components of courses specifically designated to foster international understanding and attitudes". Biology courses should break with parochial traditions (83).

EXEMPLAR CURRICULUM

USA - CHARLES F. KETTERING FOUNDATION - GLOBAL EDUCATION. Strictly speaking this interdisciplinary programme is not a course in biology. Nevertheless most of its messages are based on biological principles and with some modification it could provide the framework for a socially oriented biology programme for international education. The programme is designed for middle school and high schools in the United States and can be taught as an extra curricula element, a regular subject or by a cross disciplinary integrated approach. Its four main areas of content are (i) valuing diversity (ii) understanding the world as an interdependent system (iii) developing effective working relationships with others and (iv) understanding prevailing world conditions, the processes of change, and emerging trends (84).

(t) Sociobiology

An alternative structural approach to the biology curriculum is to abandon any attempt to treat the subject as a natural science and to organize it purely as a social science - a subject which might be titled "sociobiology" (85). In such an approach only sufficient "science" would be introduced to explain and analyse those social issues which have some biological basis. The programme would be a course about biology rather than of biology.

So far this approach has not been adopted at school level anywhere in the world - at least not so far as the author is aware. Nevertheless it is the logical extension of the more recent trends outlined in the thematic approaches described above in this chapter. Issues to be included might be concerned with bioethical dilemmas; environmental concerns; international interrelations; peace studies; family life; parenting; drugs and drug abuse; health; economic and national development and so on. The aim would be to explain the biological bases of many of the critical issues facing humankind today rather than to give a scientific training per se. The purpose would be to satisfy the needs of general education rather than of the scientific community alone.

CHALLENGE: It is likely that there will always be a need at secondary school level for a course in biology as natural science. There are cogent arguments, however, for developing an elective programme of sociobiology. This could be chosen as an optional extension of mainstream biology, or for non-science majors, as an alternative to a natural science. The challenge for curriculum designers is to design such a course to complement a secondary school natural science programme in biology.

EXEMPLAR CURRICULUM

IUBS-CBE - SOCIOBIOLOGY. So far no course has been developed in "sociobiology". IUBS-CBE has touched on this matter and has proposed some topics which might be included in such a programme. These include ethical aspects of human reproductive physiology; ecological problems; diversity and conservation including animal liberation; modern applications of genetical and evolutionary techniques; pollution, defoliants, pesticides, bacteriological weapons and food additives; behavioural and social issues such as cultural diversity, stress and mental illness, the aged and disabled in society; family life; parenting; consumerism; personal development; behaviour modification and communication and information technology (86).

2.3 Conclusion

Dorothy Rosenthal and Rodger Bybee have pointed out that present day school biology programmes have grown out of a combination of historical, intellectual and social development, which had their origin in the nineteenth century (87). They also stress that throughout its history the biology curriculum has always incorporated new scientific advances while at the same time reflecting events in the larger society. They argue that throughout its history of more than 100 years as a curriculum subject in schools there has been an explicit or implicit debate about its goals - whether it should be primarily a vehicle for teaching the science of life ie. a pure science, or whether it should be a science for living ie. should serve the individual needs of students and the needs of society (88).

In this chapter various themes for structuring the school biology curriculum have been described. They have been loosely surveyed along a continuum with the first examples emphasising the "science of life" approach and the latter emphasising "science for living". In the first part of the continuum there is a strong adherence to the structure of biology as a natural science and in the last part a move towards teaching biology more as a social science.

The continuum also represents a change across time. The first set of themes were popular in the first half of the twentieth century and into the 1950s and 1960s. The latter were strongly socially oriented themes which became more prevalent in the 1970s and 1980s. This change continues into the 1990s and will possibly continue into the next century. School biology curricula are changing in content and emphasis. These changes involve the following trends.

i) A move away from the classical structure of biology - whether it be structured by levels of organization; taxonomically; by evolutionary principles, physiologically or by whatever biological principle.

ii) A broadening of the subject matter to include a great deal of what is now regarded as social science - especially sociology.

iii) A focus on socially relevant issues rather than on biological facts or concepts for their own sake.

iv) A selection of subject matter which reflects the genuine needs of individuals and of society.

v) An emphasis on case studies with ethical implications.

vi) A methodology which fuses the classical approaches of biology with the methods of the social sciences.

vii) Teaching objectives concerned more with the personal development of learners rather than the education of research biologists.

The degree of change will of course depend on a number of factors including the purpose of any particular course of biology. At school level the purpose is to achieve the objectives of general education. At undergraduate level the purpose is to provide for both general education and for the training of professional biologists. At postgraduate level the sole purpose is to train research biologists. How far the pendulum swings in favour of a sociobiology as distinct from a classical biology curriculum is hard to say but the swing has begun and already courses are emerging which reflect these changes. One thing is clear, biology at middle school level and to an extent at senior school level is changing very rapidly and curriculum developers must be ready to meet the challenge of this change.

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Chapter 3

CURRICULUM STRUCTURES

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3.1 Introduction

The way in which curriculum and instructional materials are structured changes from time to time in response to several factors. Some of the factors which bring about these changes are: social, philosophical, political, epistemological, economic and those which may be broadly referred to as being influenced by the needs, ability and aspirations of the learner. All these factors play roles of varying importance on the curriculum offerings of the school and society.

Biology education, if it is to maintain a pivotal role in the education of citizens must of necessity be aware of, and be guided by, if necessary, these various forces. There are many examples already emerging in curriculum structures which bear evidence to the fact that biology educators are in tune with the present realities and future responsibilities (Chapter 2). The various themes at the 1985 Bangalore Conference on "Science and Technology Education and Future Human Needs" which have already been referred to is but one example. Here the emphasis was not on biology per se but science in general. However, one cannot but notice the emphasis placed on health, environmental concerns, food and agriculture and the like. Indeed some groups at Bangalore attempted to produce, albeit in skeletal form, scope and sequence charts such as "An Energy Programme for Sierra Leone Secondary Schools" (1), "Environmental Aspects of Health Education" (2) and "Food Aspects of Biological Education" (3).

There are several curriculum structures which should be considered if biology education is going to adequately meet emerging needs and future responsibilities. Some have been tried successfully in the past but there are others which require consideration. The thesis here is that biology educators must never cease to search for ways and means to make the subject area more accessible and palatable to all citizens - biologists and non-biologists alike.

The remainder of this chapter will attempt to critically examine various curriculum structures available to biology education. Some are well-known and widely-used, others are still mainly localized, and some even evoke considerable controversy. The following list of structures are by no means exhaustive but it does provide a template for discussion. Indeed there is a possibility that from in-depth evaluation of these curriculum structures an effective hybrid may emerge. The curriculum structures to be examined are:

- (a) Separate Biology
    - (i) Botany, Zoology, Human Physiology
    - (ii) Integrated Biology
    - (iii) Core and Electives
    - (iv) Life Situations
    - (v) Individualized Prescription
- (b) Integrated Science
- (c) Balanced Science
- (d) Integrated Curriculum (all subjects)
- (e) Core Curriculum

3.2 Separate Biology

Biology may take on many structures. These various structures may be used and have been used from time to time depending on the purposes for which this course is tailored.

(a) Botany, Zoology and Human Physiology

We are all acquainted with Botany, Zoology and Human Physiology, the form in which separate biology was taught in earlier years. This structure tends to present the subject as discrete entities, sometimes neglecting to forge the links between them. True, this orientation allows for more in-depth treatment of certain topics, especially taxonomy, life cycles and morphology, but in situations where any one of the areas is left out or not well-handled, the learners tend to get uneven and lopsided views of biology. In the majority of cases this structure is being replaced by one in which the subject is treated as an integrated whole.

(b) Integrated Biology

Integrated biology is usually referred to simply as "biology". In this orientation the various characteristics of life are looked at across both the plants and animals. That is, concepts, principles and theories are studied as they relate to both the plant and animal kingdoms. The structure allows for important linkages that may be ineffective in the case of separate botany, zoology and physiology. Besides, it eliminates the many areas of overlap that may exist.

This structure represents an improvement on the one where botany, zoology and human physiology are taught separately. The main drawback is that it does not always take cognizance of the interrelatedness between biology and the other sciences. This interrelatedness spawns the areas such as biophysics, biochemistry and so on which in themselves are becoming forms of knowledge in their own right.

(c) Core and Electives

Sometimes in an effort to deal with the explosion of knowledge in the field, as well as to facilitate learning for a broad band of abilities encountered in the learning situation, a structure of core and electives is used in biology. The structure also allows for learning in differing geographical and cultural backgrounds. The intention in this structure is to provide a broad-based set of concepts, principles and theories for all learners. This is the core. The electives provide the built-in flexibility to cater for the peculiar needs of a variety of learners. It also allows learners to be selective in what they learn and to what depth.

The structure therefore has distinct advantages which should help in the popularization of biology.

(d) Life Situations

The Education Commission of the International Union of Biological Sciences (IUBS-CBE) in producing "A Strategy for Biology Courses for Undergraduate Non-Biology Students" in 1987 uses the Life Situation approach or structure. The introduction to the report of this project spells out the philosophy very clearly as follows (4):

> "In the last three decades since World War II people are realizing with growing awareness, how far biological phenomena are represented in various fields of everyday life and how hopeless the attempt is to solve our big political and personal problems without a sufficient amount of biological knowledge and, more essentially, biological thinking. Problems of pollution and conservation of our environment, of health and disease, and even of human behaviour are much interwoven with biological phenomena but they must not even be recognized to be biological problems without the necessary biological knowledge.
>
> It is not intended to argue here that biology is the complete science which can solve all problems of human life, but that an understanding of biological principles is a necessary precondition for solving many human problems. In other words, many vital human problems are not solvable without a biological input, but the converse is not true.

> On the basis of this general conviction it has to be decided how much and what kind of biology the citizens of our world have to know in order to be able to master their own private lives and to occupy positions of high public responsibility.
>
> It seems natural, from the standpoint of motivation, that non-biology students will not have a primary interest to study biological subject matter in the way that biology majors do, ie. in the categories 'genetics', 'evolution theory', 'physiology' etc. They will be rather more motivated by questions round their own personal life and will be interested to study those biological topics which are obviously related to these questions. That means, their interest in biology will only be of a secondary kind, and this has to be borne in mind when planning biology courses for non-biology students."

The science educator S.B. Robinsohn (5), in the context of general curriculum theory, has suggested a planning scheme which does not start from the scientific subjects, but from life situations which a student is likely to become involved with now or later on. This "situation approach" leads to the question what kind of knowledge a citizen needs in order to master the most important situation of his or her life. Only when we have the answer to his or her question can courses be sensibly planned and organized. The Robinsohn strategy may be illustrated by the following diagram.

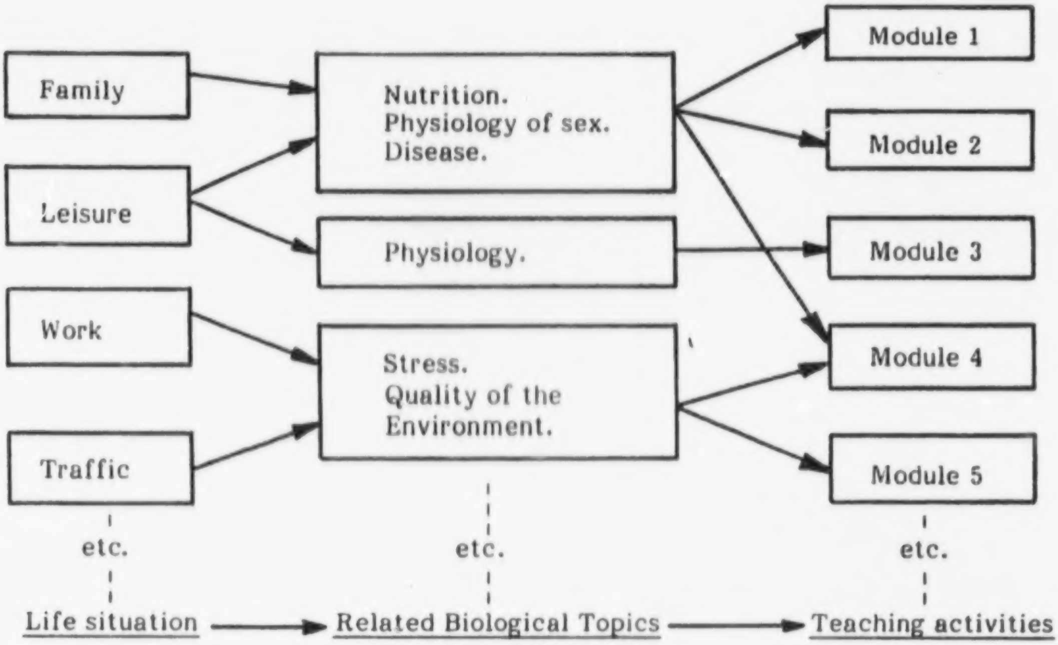

Family
Leisure
Work
Traffic
etc.
Nutrition.
Physiology of sex.
Disease.
Physiology.
Stress.
Quality of the Environment.
etc.
Module 1
Module 2
Module 3
Module 4
Module 5
etc.
Life situation
Related Biological Topics
Teaching activities

Figure 3.1: The "situation approach" in curriculum planning

In the Federal Republic of Germany the "Rahmenplan des Verbandes Deutscher Biologen" (Outline syllabus of the Association of German Biologists 1981) and the "Hessiche Rahmenrichtlinien Biologie" (Guidelines in Biology for the Country of Hessen 1978) are based upon this situation approach (6). Their influence upon the motivation of students and adults (including politicians!) for biology has been remarkable. So it seems worthwhile to construct biology courses for non-biology students on the same curricular basis, that is, to develop a chain of biological concepts leading from the life situations.

As examples of life situations, which should be of general interest for all students independent of their special field of studies, the following four have been chosen to illustrate the strategy proposed here:

1. Family life
2. Leisure activities
3. The working place
4. Traffic and transport.

It is evident that all four situation areas would require a great variety of biological topics in order to be fully understood. So the area "family life" implies the treatment of themes such as the following:

- nutrition (→ agriculture → ecology, physiology of plants, physiology of man etc.)
- hygiene (→ diseases → microbiology, pharmacology etc.)
- sexuality (→ genetics, evolution → recombination cytology, hormones, etc.;
    → growth, development → morphogenesis;
    → sex behaviour → instincts/learning, etc.;
    → related topics in physiology/psychology/sociology)
- social life (→ social biology → instinct mechanisms, modes of learning, territoriality, aggression, etc.)

This situation-centred grouping of biological knowledge would result in some repetition of the same or similar subject matter in the different modules. For example, the theme "reflexes in our nervous system" would appear in a module on "family life" as well as in "working place" and "traffic". The whole system of information contained in the modules is redundant with respect to biological topics. This redundancy is the price we have to pay to motivate non-biology students to appreciate the usefulness of biological knowledge in their everyday lives.

The associative framework of biological concepts should not be restricted merely to personal situations of life. All teaching modules also have to provide associations on the local, national and international (global) level. The strategy will be to convert the more supra-personal levels to personal ones by means of associations brought about by the teaching process. Figure 3.2 shows a concentric scheme of associations which have to be aimed for in each teaching module. The centrifugal arrows demonstrate the possible sequence of teaching in time (from personal interests to global ones); the opposite, centripetal arrows illustrate the teaching objectives; conversion of global, national, local interests into personal ones in the mind of the learner.

Figures 3.1 and 3.2 symbolize the main strategies of this type of project.

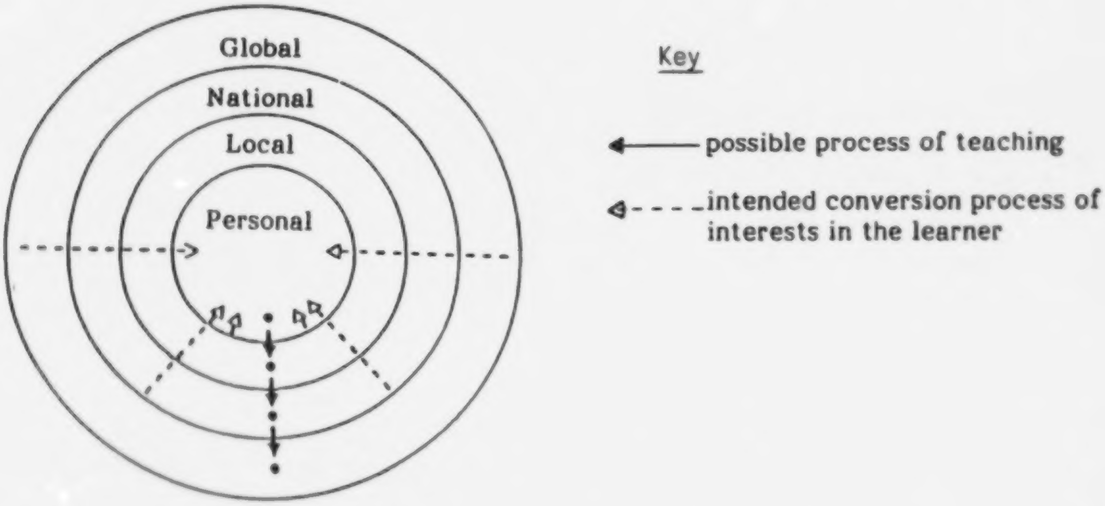

Global
National
Local
Personal
Key
possible process of teaching
intended conversion process of interests in the learner

Figure 3.2: Strategy of concentric associations round biological topics.

(e) Individualized Prescription

Under this structure there is an attempt to provide learning/ instructional situations that are specifically designed to cater for individual abilities and needs. The net result would be that everyone will proceed at his or her own pace undergirded by interests of the learner. Certain well-known methods and structures exist eg. contract learning, mastery, rap sessions, peer tutoring, visits to zoos and wildlife parks, community lectures, library and audio-tutorials, labs. A closer look at some of these should illustrate how these structures may meet emerging dimensions and future responsibilities of biology education.

Take for example the use of peer tutoring. It is well known that ever so often learners are better able to grasp and develop a concept if one of their school mates or peers explains the matter to them. This is sometimes successful after many futile attempts by teachers. The method has tremendous possibilities, indeed it produces a powerful motivating tool especially for those who are entrusted with the tutoring role.

Visits to zoos and wildlife parks also allow for individualized learning in biology. Biology education, especially at the secondary level, may use this to great effect. In looking at the "Out-of-School Science Activities in Malaysia", Professor Siew Cheong lists visits to zoos, museums and agricultural stations as some of the activities undertaken by Science Societies (7). She lists specifically that

> "the Malaysian Zoological Society has established the Zoo Negara Education Centre whose concern is with the education of youths and adults in wildlife and its conservation....The Department of Wildlife and National Parks in co-operation with the Ministry of Education has set up a Nature Study Centre....The Centre is an ideal place to study the natural habitats of tropical wildlife, ecological balance, jungle tracking and the variety of flora and fauna in the tropical forests." (8)

The use of visits to zoos helps also in the popularization of biology, forging as it does the links between what happens in classrooms with society at large.

3.3 Integrated/Unified Science

J. Rutherford critically assesses the main reasons given for teaching integrated science thus: "The case for integrated science is predicated on assumptions about the natural world, science students and societal needs" (9). In telegraphic brevity these are:

- The natural world is a unified whole. Our present lack of knowledge may prohibit us from perceiving that unity in all its complexities, but to the extent possible science should try to illuminate the whole rather than the mere fragment that each separate discipline concerns itself with. Questions: How can a teacher ever get to know enough about the astronomical, atmospheric, ocean, earth, biological and physical sciences - not to mention mathematics and the behavioural and social sciences - to be able to teach unified content? Unless teachers will agree to substantially broaden their knowledge of science by studying sciences outside of their own field, is there any way they can become prepared to teach an integrated view of the world (or any part of it)?

- Science itself, as distinct from nature, is moving toward integration in content and method. More and more separate conglomerates of knowledge are being assembled into a conceptually unified structure, just as techniques are shared across disciplines. The rapid development of molecular biology provides a dramatic but not atypical example of what happens when different sciences join hands. Questions: Can a teacher trained in substance, techniques and style of one science learn those things about one or more other science domains without extensive retraining? Can a teacher learn "integrated science" de novo? Will he or she even try if it takes them into areas of science about which they have no personal interest?

- Technical and career education aside, students are rarely interested in the kinds of questions that relate to the theoretical structure of a given scientific discipline. Instead they wonder about the real world of their everyday lives. Such matters willy-nilly cut across discipline boundaries, and therefore so should science teaching if it wants to capitalize on natural student interest. Question: Since different students have different science-related interests, how can any one integrated science course deal with them any better than a discipline-structured one?

- The major societal issues of our times - disease, overpopulation, resource depletion, environmental degradation and the like - are linked to science and technology. If citizens of the world are to deal effectively with such issues, then surely the need is to understand science broadly and in the context of those problems rather than narrowly in the context of compartmentalized disciplines. Questions: How can teachers develop the vast knowledge it would take to deal with so many problems scientifically? How could they keep up to date in several sciences simultaneously? Can they learn to deal with science-related social issues in a non-biased way?

He also, using the Varna conference proceedings, attempts to say what integrated science really is:

> "Integrated science teaching requires...joining several subjects into a single course in which concepts of science are presented through a unified approach". (10)

In terms of content he includes the following examples, which show wide variety:

- Courses that merely blend material from different subdivisions of a single major discipline.

- Those that select material from two or more separate sciences.

- Some that join one or more of the natural sciences with mathematics or with material from social sciences, arts or humanities.

- And those that put material from one or more sciences together with applied science and technology.

Rutherford remembers from a previous paper that the format provides even greater diversity:

- The conceptual scheme approach in which the overarching ideas of science (conservation of energy, evolution, ecological balance, atomicity etc.) provide the unifying thread.

- The inquiry approach in which solving problems and answering questions about the natural world takes precedence over particular content.

- The relevance approach in which the content is organized around questions of the social utility and impact of science and technology.

- The process approach in which engaging students in doing science, any science, is considered to be more important than student mastery of a prescribed body of scientific knowledge (11).

V. Showalter in making the case for teaching science as a unified whole emphasizes that:

> "Science knowledge that applies to plants and rocks may, on the surface, seem to be different as are the plants and rocks but on close examination the nature of this knowledge is the same - the separate sciences of botany and petrology are integral parts of the larger science. Their difference can be thought of as differences of degree rather than of kind". (12)

Winston King builds a rationale for teaching integrated science under the following headings (13):

- the search for unity
- the needs of society
- the needs of the students
- practical reasons
- the need for a general (liberal) education.

King quotes Malek (1971) to make the point on the search for unity:

> "In the development of science, the frontiers of the various disciplines are in constant and continuous movement, new boundary-disciplines are interdisciplinary, but which are gradually established as new disciplines (eg. biochemistry, biophysics, physical chemistry, biotics, bioengineering). Even when they are fully established as individual disciplines then teaching needs to be very much of an inter-disciplinary nature to enable the new discipline to develop further..." (14)

King concludes that:

> "There are some problems involved in teaching integrated science; many however are attitudinal. There is a great reluctance to change from one's specialized areas into, what appears to be, unknown territory. On the other hand there are several powerful arguments for teaching science as a unity." (15)

D. Chisman (16) in response to the question: "What are the main issues in integrated science today?" suggests that there are real obstacles:

> "In addition to the familiar problems that beset many systems ie. overburdened teachers, lack of status of teachers, lack of adequate training of teachers, the following issues are among the most important:
>
> - The apparent dichotomy between the wish to provide scientific literacy for all, and the need to prepare future scientists and technologists.
> - The need to orient the content towards future trends in science and technology, including trends that have an international dimension....
> - A recognition of the disintegrative nature of content-based testing in integrated science courses....
> - The limitations of the teacher training systems world-wide in preparing teachers adequately to teach integrated science, at primary and secondary level....
> - The genuine fear of many teachers of the challenges of change in science and technology and a lack of motivation to tackle integrated science..."

The question for biology education is whether the integrated science structure will provide sufficient groundings in biological knowledge and skills to serve both those who will become biologists, and those for whom the course is terminal.

At the primary level the problem seems not to loom too large. At the secondary level, however, where students and parents begin to set their sights on tertiary education there is much more controversy. The situation is exacerbated by the stance of some universities which are themselves established on the principle of separate sciences.

There is room for compromise on this issue. Maybe we should offer a broad-based science up to 16+ and then build on that foundation at the higher levels. This should go some way towards allowing education for scientific literacy and also for background for those who will specialize in the sciences.

3.4 Balanced Science

The last point made seems to be at the heart of the movement towards "balanced science" in the United Kingdom. The Chairman of the Science Working Group of the National Curriculum in a letter to the Secretaries of State (June 30, 1988) sets out the Group's recommendation for attainment targets and programmes of study for Science 5-16 and for Technology 5-16. The Group also suggests profile components of science to cover four interrelated aspects of the subject - "knowledge and understanding; the skills of scientific investigation; skills of communication; and awareness of the impact of science on the individual and on society" (17).

The Chairman's recommendations are perhaps most noteworthy in the area of the curriculum structure espoused.

> "You [the Secretaries of State] also said we should assume that the majority of pupils in years 4 and 5 ought to follow a balanced science course occupying no more than 20% of curriculum time and leading to a double GCSE certificate.... At all levels our recommendations may be implemented through a range of organizational patterns - for example, 'balanced' science which combines the disciplines of physics, chemistry and biology into a single course; or 'separate subject' science where, for teaching purposes, the attainment targets are grouped into units of physics, chemistry, biology and the earth sciences....The Group's firm view is that all pupils should follow the full programme we have recommended, leading to a double certificate examination at GCSE, and providing a basis for higher level study of science in the sixth form and beyond....It is important that all pupils - not just those who will go on to become scientists and engineers as adults - are equipped at school with a foundation of knowledge and understanding of science." (18)

The List of Attainment Targets for Sciences 5-16 and Technology 5-11 is given in Table 3.1 (19). While the profile components are shown in Figure 3.3 Each Attainment Target is further sub-divided into objectives for the learners, with careful breakdown of the level at which each objective should be achieved.

Table 3.1 List of Attainment Targets

Science Curriculum 5 to 16 (UK)

---

1. The Variety of Life
2. Processes of Life
3. Genetics and Evolution
4. Human Influences on the Earth
5. Types and Uses of Materials
6. Making New Materials

7. Explaining how Materials Behave
8. Earth and Atmosphere
9. Forces
10. Electricity and Magnetism
11. Information Transfer
12. Energy Transfers
13. Energy Resources
14. Sound and Music
15. Using Light
16. The Earth in Space
17. Exploration and Investigation: Doing
18. Exploration and Investigation: Working in Groups
19. Communication: Reporting and Responding
20. Communication: Using Secondary Sources
21. Science in Action: Technology and Social Aspects
22. Science in Action: The Nature of Science

Note: Attainment targets 6, 7, 13 and 21 and 22 do not apply to 5 to 11 year olds.

Technology Curriculum 5 to 11 (UK)

1. Technology in Context
2. Designing and Making
3. Using Ideas of Forces and Energy
4. Communicating Technology

5...........7	7...........11	11..........14	14..........16
Exploration	Investigation	Investigation	Investigation
Communication	Communication	Communication	Communication
Knowledge and Understanding	Knowledge and Understanding	Knowledge and Understanding	Knowledge and Understanding
		Science in Action	Science in Action
Technology	Technology		

Figure 3.3: The profile components for science and technology curricula 5 to 16 (UK)

The Department of Education and Science (DES) document commends the number of schools which, recognizing the desirability of a broad and balanced science education within a reasonable but not excessive proportion of time. The document sees the developments as having four main tasks:

(i) preparation for the possibility of post-16+ work in the separate sciences;

(ii) provision of insights into important scientific ideas;

(iii) assistance to think and operate in a scientific manner;

(iv) Equipping future citizens for life in an increasingly technological society (20).

Perhaps one of the most important contributions of the DES document is the way in which it conceptualizes various models of organization. These, in a very real sense, summarize many of the ideas already mentioned in this chapter. Figure 3.4 shows these models and the attainment targets (21).

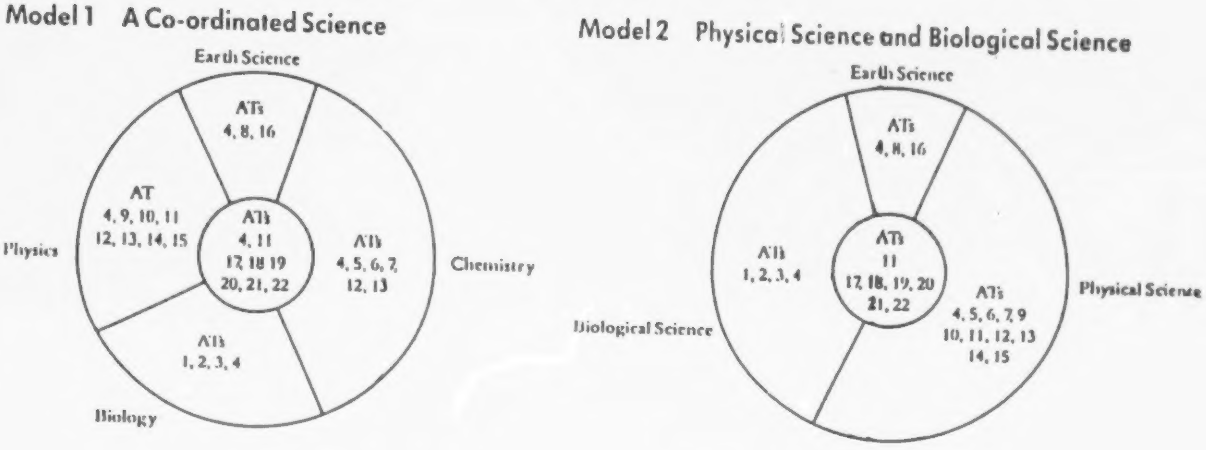
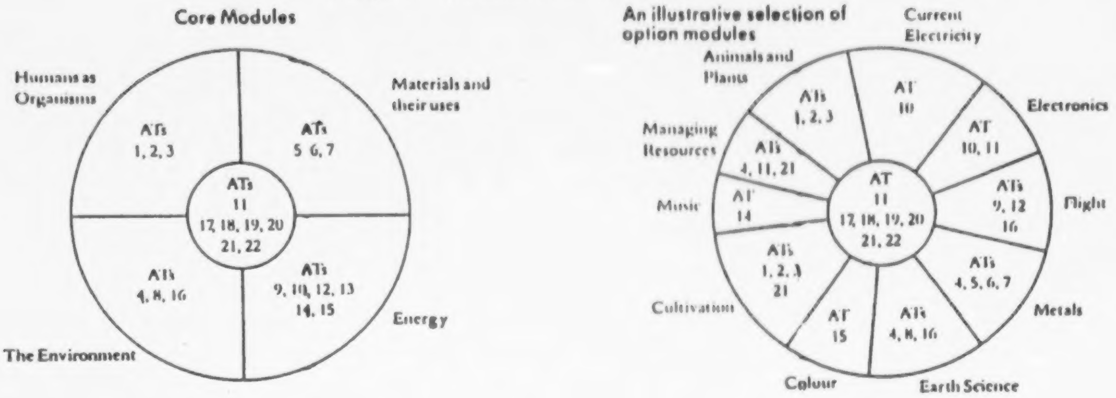

Model 1 A Co-ordinated Science
Earth Science
ATs 4, 8, 16
AT 4, 9, 10, 11 12, 13, 14, 15
Physics
ATs 4, 11 17, 18 19 20, 21, 22
ATs 4, 5, 6, 7, 12, 13
Chemistry
ATs 1, 2, 3, 4
Biology
Model 2 Physical Science and Biological Science
Earth Science
ATs 4, 8, 16
ATs 1, 2, 3, 4
Biological Science
ATs 11 17, 18, 19, 20 21, 22
ATs 4, 5, 6, 7, 9 10, 11, 12, 13 14, 15
Physical Science

Figure 3.4: Attainment Targets and Models of Organization

Model 3 Modular Science (core + options)


Core Modules
Humans as Organisms
ATs 1, 2, 3
Materials and their uses
ATs 5 6, 7
ATs 11 17, 18, 19, 20 21, 22
ATs 4, 8, 16
ATs 9, 10, 12, 13 14, 15
Energy
The Environment
An illustrative selection of option modules
Current Electricity
Animals and Plants
ATs 1, 2, 3
AT 10
Electronics
Managing Resources
ATs 4, 11, 21
AT 10, 11
AT 11 17, 18, 19, 20 21, 22
ATs 9, 12 16
Flight
Music
AT 14
ATs 1, 2, 3 21
ATs 4, 5, 6, 7
Cultivation
AT 15
ATs 4, 8, 16
Metals
Colour
Earth Science

Model 4 An Integrated Science

Model 5 Science in everyday contexts

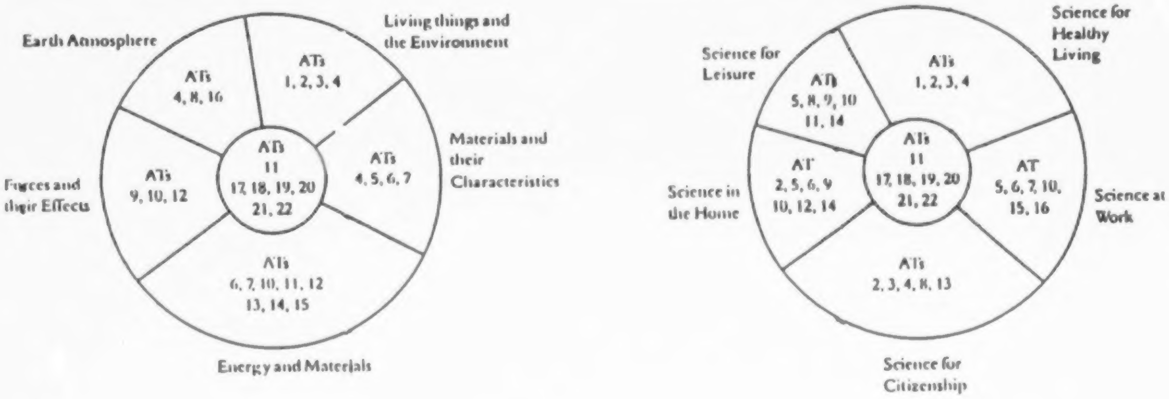

Earth Atmosphere
ATs 4, 8, 16
Living things and the Environment
ATs 1, 2, 3, 4
Materials and their Characteristics
ATs 4, 5, 6, 7
ATs 11 17, 18, 19, 20 21, 22
Forces and their Effects
ATs 9, 10, 12
ATs 6, 7, 10, 11, 12 13, 14, 15
Energy and Materials
Science for Leisure
ATs 5, 8, 9, 10 11, 14
ATs 1, 2, 3, 4
Science for Healthy Living
ATs 11 17, 18, 19, 20 21, 22
Science in the Home
AT 2, 5, 6, 9 10, 12, 14
AT 5, 6, 7, 10, 15, 16
Science at Work
ATs 2, 3, 4, 8, 13
Science for Citizenship

Figure 3.4: Continued.

3.5 Integrated Curriculum (all subjects)

The structure suggested in an integrated curriculum is that all subjects should feature in the teaching/learning transactions.

From the examples that are well-known the structure seems most suitable for the primary level. At this level the emphasis is on the acquisition of broad, basic ideas, skills and attitudes. Clearly there is no attempt to introduce concepts, principles and theories. At the secondary level, however, one would expect much more of the handling of science and other concepts.

There is some doubt as to whether biology education would be really well served in the use of the integrated curriculum at all levels of the educational system. Many biology educators will disagree that such will provide the preparation for further study, sufficient insights in biological ideas and the groundings for bioliteracy.

3.6 Core Curriculum

In many countries the structure envisaged in a core curriculum is one in which the learner is exposed to fundamentals that would serve him or her for living in society.

The U.S. curriculum authority Hilda Taba describes the core curriculum as:

> "This type of curriculum organization was supposed to develop integration, to serve the needs of students, and to promote active learning and significant relationship between life and learning....A large portion of curriculum patterns which are designated by this name represent nothing more than a method of distinguishing the portions of curriculum required of all students from those which have specialized functions or are elective." (22)

It seems that in this structure whatever biological materials are used, at least the starting point of any learning unit can be made from some experiences familiar to the students.

The generally accepted criticism of aspects of core curriculum "is their failure to offer significant and systematic knowledge. This weakness is caused by the same difficulty which has been typical of several other attempts to deviate radically from the subject organization - that is, insufficient attention to the implementation of the design" (23).

3.7 Conclusion

The chapter outlines, with examples, the various curriculum structures that are present in biology education. It also describes certain other structures which are available, pinpointing the pros and cons of each.

In the final analysis biology educators must be sure that whatever structure or hybrid of structures that is used, the overarching aims and objectives of biology education must be paramount. These aims and objectives must revolve around preparation of students for life in an ever changing and technologically complex society. They must on the one hand cater for bioliteracy, but on the other they must provide the rigour for those who will specialize in biology.

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Chapter 4

BIOLOGY FOR GENERAL EDUCATION

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4.1 Introduction

Biology for general education consists of a programme of non-specialized learning from the primary to the secondary school level deemed essential for all. However, for some students, biology learning stops at junior secondary, for others (those intending to enter the university), more biology courses are taken at a higher level. The latter may be compared to the life science component of Natural Science courses in the General Education programme at the university level in some countries.

As any other science subject in the secondary curriculum, biology attempts to prepare the student for several possibilities, for example, advanced course studies in a university or post-secondary technical institutes, or to serve as terminal education for those not taking further education. Hence, effort is made to incorporate technology, practical work or livelihood projects that are science-based in the curriculum.

4.2 Biology Teaching from the 1960s

The recent evolution of biology in the school curriculum started in the early 1960s with the curricular reforms initiated by the Biological Science Curriculum Study (BSCS) in the United States and the Nuffield Science Project in the United Kingdom. Many other countries adopted or made adaptations of the BSCS or Nuffield materials. Subsequently, educators developed indigenous syllabi to suit particular educational needs and situations in their own countries.

The development of new thinking in biology education has been influenced by the changing emphasis in science education. The vastly expanding knowledge of biology and its effects on almost all facets of human life resulted in the revision of school biology curricula. This is characterized by the integration of more updated knowledge with methodologies of discovering it. As a result of the new orientation, the following changes occurred:

- Modification of the biology content particularly in the field of cell biology, molecular biology, physiology, genetics and ecology with aspects related to human biology.

- An increased emphasis on the process of biological investigations and greater encouragement of individual and relevant learning through project and experimental work.

- A deliberate effort to encourage students' participation in organizing and pursuing their own learning, particularly in relation to practical work.

- A shift from taxonomy and comparative anatomy (characteristic of the period before 1960) to relationship of structure and function through use of selected animals and plant types.

- Inclusion of the learning of skills such as section-cutting and staining in plants and dissection of animals in upper secondary biology courses.

These changes reflect an attitude that encourages the teaching and learning of biology for its implication and application in everyday life rather than the acquisition of scientific skills and pursuit of science.

In the 1970s, the world was confronted with crucial issues of energy, population and environmental pollution. Nations came to realize the finiteness of natural resources which were being depleted at a rapid rate. It was then widely discussed that population control, pollution control and prevention, conservation of natural resources, and recycling of materials should be given emphasis in the curriculum. This required active measures based on sound science principles particularly in biology. This brought in a new perspective to the school biology teaching in relation to new fields of study such as human and social biology and environmental science. The integration of the social dimension to biology teaching both in terms of dealing with areas of biology such as ecology, evolution and behaviour, and its implications to society has linked biology more closely with the social sciences.

More recently, there have been developments in microbiology, genetics, and molecular biology which highlight new trends in biotechnology.

4.3 Goals and Objectives of Biology Education

A review of the objectives of the biology curricula of different countries indicate global goals that are, however, articulated somewhat differently. These objectives converge on the four goals of science education as follows:

1. Knowledge: To develop knowledge of facts, terminology concepts, generalization and principles which help students confront and interpret their environment.

2. Process: To develop intellectual processes of inquiry by which scientific problems and phenomena are explained, predicted and/or controlled.

3. Skills: To develop the student's ability to handle, construct and manipulate materials and equipment in a productive and safe manner, and to develop an ability to measure, organize and communicate scientific information.

4. Attitudes: To develop students' attitudes of curiosity, wonderment about nature and involvement with natural phenomena.

Each goal is as important as the other. Thus, equal emphasis is given to each of the four goals.

These goals are translated into general objectives or aims as shown in the following list culled from teacher's guides and syllabi currently used in some countries:

- To promote an appreciation of the importance of experimental, investigatory work in the study of biology.

- To develop a range of manipulative skills and ability to use those skills appropriate to the subject.

- To develop the ability to use skills to identify and solve practical problems.

- To develop an interest in and enjoyment of the study of living organisms.

- To encourage an attitude of curiosity and scientific enquiry.

- To promote respect for all forms of life.

- To make young people understand that biology is a unique and powerful way of knowing about the natural world.

- To present biology as an unending search for meaning rather than as a body of dogma.

- To teach that science relies on curiosity, creativity, observation, analysis, continuous questioning, and, perhaps most important, critical thinking.

- To acquire not only an intellectual and aesthetic appreciation for the complexities of living things and their interrelationships in nature, but also for the ways in which new knowledge is gained and tested, old errors eliminated, and an ever closer approximation to truth is attained.

- To present a method for investigating and testing their own environment in a future culture dominated by technology. As participants in democratic society, these young adults will be responsible for the maintenance of their country and possibly the world, in a condition that provides a healthy and viable environment for themselves and future generations.
- To present societal issues that grow naturally out of science since it is within the societal context - not the scientific - that the average student will grapple with these problems.
- To acquaint pupils with applications of biological theories and patterns.
- To train and prepare young people to deal with environmental problems in the face of global changes in nature brought on by human activities that threaten life on earth.
- To teach the scientific principles of nature protection and gain a deep understanding of the need to respect nature and to use natural resources with care.
- To prepare young people for participation in material production.

4.4 Content and Teaching of School Biology

(a) General Trends

Most new curricula are child-centred. John Dewey proposed in the early part of the twentieth century that learning occurs best under conditions the learner values. Affective and cognitive objectives are given equal emphasis in the new syllabi which provide for the total development of each individual.

Relevancy of materials and experiences to the needs of the individual is also a primary consideration. Knowledge of content and intellectual development are used as means to an end.

The prominent features of new curricula are: new and exciting teaching methods; emphasis on relevance; and the teaching of applications of different concepts.

Many curriculum materials reflect a consciousness toward achieving balance between acquisition of knowledge and development of scientific skills and processes. Situations that have immediate significance to pupils, both in terms of their inherent interest and their evident connections to the real, everyday world are often utilized. Many present biology within the context of a practical problem or in relation to a real-life activity. This teaching approach situates science closer to the real world. Science is not thought to exist in isolation from society; social and moral problems can arise in the course of any scientific study. Attention is given to the applications and issues involved in the interaction of science and technology with society.

The content of biology is used as a vehicle for developing problem-solving skills in socially meaningful topics such as personal and community development. This approach was especially the rule during the 1970s. Public examinations then were seen in part as devices for speeding up the evolution of biology teaching away from inquiry learning for its own sake towards inquiry learning for the achievement of meaningful socially relevant objectives.

In many syllabi, the environment is the focus of the course. The rationale is that environmental topics provide opportunities for pupils to discuss problems for which there are no definite right answers. This encourages pupils to debate or give their views based on scientific knowledge and understanding of the issues.

(b) Trends in Selected Countries

The following is a brief description of the content of various school biology syllabi developed in several countries.

Britain

The integration of science, technology and society are evident in these syllabi of England and Wales (1):

MEG Syllabi:

Biology A emphasizes some aspects of biology which are relevant to everyday life.

Biology (Human) emphasizes some social and technological applications.

NEA Syllabi:

Biology A places a greater emphasis on principles; it has several references to work in relation to a personal, social, economic and technological dimensions.

Biology (Human and Social) emphasizes principles rather than rote learning. The environmental and botanical elements of biology are generally integrated into the syllabus with human aspects drawn in. The other feature is the exploitation by humans of natural resources. There is a strong emphasis on social applications of biology as would be expected from the syllabus title. The economic and technological aspects are somewhat less evident.

SEG Syllabus:

> Biology has reasonable coverage of personal, social, economic and technological applications.

WJEC Syllabus:

> Biology A and Biology (Human) have a good coverage of social and technological applications.

Also in Britain the Nuffield programmes have a societal orientation. Nuffield Science Year 9 (for pupils aged 11 to 16) serves to develop knowledge, skills and an understanding of processes (2). It is activity based, in support of the idea that learning is a pupil-centred, active process. Many of the activities are in the nature of experiments, games, classroom competitions and SATIS (Science and Technology in Society)-style inquiries. Such activity-based learning coincides with the developing maturity of pupils who can increasingly be encouraged to learn for themselves rather than simply to listen to others. It serves as a conclusion to the exploratory phase of science in earlier years.

The course is interdisciplinary. It presents various chapters with a global perspective. It is explained to teachers that teaching science with this orientation can appeal to young people and help them relate scientific theory to their experiences in and out of school. The approach seeks to link up with geography, history, economics, social studies, local, national or international issues which are in the news at the time the topic is taken up in class.

Students give and support their view about environmental issues concerned with the use of fertilizers in agriculture and horticulture based on their practical experiences. They are guided to realize that the balance of materials in a biological community can be maintained by recycling these materials and that human activities can affect this natural process. They are led to recognize that the extinction of any species will have an effect on the remaining species in a community.

The issue of the responsibility of scientists and the potential of science for good and bad is likewise presented. The impact of industry and farming activities on the balance of natural processes in the environment is also studied.

Nuffield Coordinated Science (1989) presents in the biology section various situations which give students the opportunity to realize this objective: to understand that all organisms interact with each other and with the environment in which they live (3). For example, students are asked questions such as:

> "Does it matter if natural habitats are damaged or destroyed?
>
> "What do you think of re-introducing the brown bear and the wolf into Britain? These animals used to live here but all were exterminated."

> "You are a successful furniture manufacturer, specializing in high quality furniture made from tropical hardwoods. What is your attitude as people become more and more concerned about the destruction of tropical forests?"
>
> "How can you justify halting farming's damage or destruction of natural habitats to a peasant farmer desperate for the survival of his family?"

Two interdisciplinary activities are deemed appropriate for this concept: 1) case studies which use interdisciplinary approaches to tackling technological problems, for example in agriculture, in medicine, 2) investigations which require students to draw on their knowledge and skills as they tackle a problem which cuts across boundaries of several disciplines.

The United States

In the United States ecology and evolution form the main themes of the 1987 BSCS Green Version (4). The other concepts are woven into these themes, that is, diversity of types and unity of pattern in living things; the genetic continuity of life; the biological roots of behaviour; the complementarity of structure and function; regulation and homeostasis in the preservation of life in the face of change; science as inquiry; and history of biological concepts.

The underlying philosophy in the Green Version is: "Humankind's future and that of the earth depend on an understanding of humans as participants in the biological community".

Biology examines all aspects of life: structure, function, behaviour, relationships within the environment, and evolutionary history. In trying to understand these aspects as they relate to human beings, the biologist must take note of social systems as well. It is imperative that we understand how our actions influence the biosphere.

Technological solutions are available for many biological problems, but often these are not used because the situation is complicated by social factors - economic, political, psychological, religious, moral, or ethical. A complete understanding of humans, therefore, cannot be attained from the study of a single discipline. The study of biology no longer can be restricted to biological knowledge; it must be interpreted in a social context.

The science, technology and society emphasis is strong. It also presents situations where students exercise their decision-making skills. It confronts students with controversies and issues that derive from biological progress (for example, contraception, abortion, prenatal diagnosis and genetic screening). These issues call into question the validity of many long-standing values and moral traditions. That does not mean that those values and traditions will necessarily be found wanting. It does mean that new knowledge and new technologies raise what once were intellectual abstractions to the level of hard, often painful, reality for individual families and policy makers.

BSCS adopts the view that an introductory course in biology should not make controversial issues its central thesis, neither should it evade such issues when they arise naturally from the scientific content.

The teacher's guide gives suggestions for dealing with potentially controversial issues where they arise.

Soviet Union

In the Soviet Union, a unified, integrated biology course has been created. This replaces the traditional division into four separate courses (botany, human anatomy, physiology, and hygiene and general biology). The single subject of biology consists of interrelated sections: I. Plants, II. Bacteria, Fungi, Lichens, III. Animals, IV. Man and his Health, V. General Biology.

The new course content has an ecological/environmental orientation aimed at increasing public awareness of environmental issues in the age of scientific and technological growth. This is developed through the grades:

- Grade V: The plant as an integral part of nature, the proper use of natural resources, their reproduction; photosynthesis relating to the need for controlling air pollution, and protecting flowering plants;

- Grade VI: Effects of economic activity on the variety of flowering plants, protection of rare plant species, role of wilderness areas, nature parks;

- Grade VII: Practical and aesthetic value of insects, the need to protect the variety of insect species, effect of human activity on fish populations, the need to make rational use of fish resources;

- Grade VIII: Hygiene aspects of environmental protection such as becoming familiar with the harmful effects of pollution on organ systems;

- Grade IX: Effects of economic activity on the structure and reproduction of populations and of the living nature. Hygiene education as part of the secondary school biology includes personal hygiene, sex education, preparation for family life, effects of physical work and sport.

The school biology also has a polytechnical orientation. It presents and explains biological laws and patterns, together with those principles of operation of modern industry and agriculture which makes use of biological systems (5).

Bangladesh

In Bangladesh, science at the primary level (ages 6-10) is in the form of nature study. Agriculture, health and nutrition form one cluster and biology another. At the secondary level (ages 11 to 17) some aspects of the environment are combined under society and some aspects under science. Integration is based on problems of food, clothing, housing, health, cleanliness, water and air.

West Africa

In West Africa, biology at senior secondary school level has replaced separate courses in botany and zoology. Human physiology is added to the combined disciplines. The approach is less technical and more practical. It focuses more on the lives of the learners and uses materials relating to:

> Health (personal and public, physical fitness, food nutrition, disease, safety, mental health, etc.);
>
> Reproduction, heredity and effect of the environment (as related to personal and social problems, individual and group differences, improvement of living organisms, etc.);
>
> Conservation of living things;
>
> Structure and functions of living things, especially of the human body;
>
> Conditions necessary to support life and adaptations of living things;
>
> Living things of the past, and the changes that have occurred;
>
> Relations between individuals and groups and among living things in general.

A biology book for West African schools starts with explanation of biology as the Science of Life, then proceeds to simple classification of living organisms, life processes in plants and animals, ecology and genetics. It gives common names of organisms in the country (6).

China and Hong Kong

In China, most senior secondary schools' curricula emphasize the relation between technology and society. Students study the natural world, and learn the concepts of science which relate to health, agriculture and forestry that affect individual, family and social life. The major aim is to improve the students' problem-solving ability and develop their intelligence. Such reforms aim to improve the quality of secondary education which will serve as a basis for China's social reconstruction in both the material and spiritual levels.

In Hong Kong, the trend is towards science/biological education for general education and scientific literacy. There is a shift from Knowledge Studies to Issue Studies. Some characteristics of Issue Studies are: emphasis on problem-solving and decision-making; motivation derived from social and/or individual action, high moral load; and eclectic integration. There is a link between science education and the needs of society vis-a-vis the realities of peoples' lives.

Philippines

In the Philippines, elementary science programmes aim to help children gain a better understanding of the world around them and their place in the environment. They aim to transform the child from an inward-looking egocentric creature to an outward-looking, helpful member of society who manifests concern for fellow human beings and care for the earth's resources. Such a child is envisioned to regard his or her own person and physical body as a wonderful and unqiue creation worthy of utmost care and respect. The child is consequently expected to regard fellow human beings, other living things and all of the earth's resources upon which he/she depends for survival and sustenance in the same manner (7).

Thus, syllabi emphasize relevant concepts dealing with health and life, as well as physical and earth sciences. These subjects are interlinked with appropriate thinking, processes and skills to enable the child to make informed, sound decisions and solve problems concerning oneself, fellow human beings and the environment. The development of decision-making and problem-solving skills is necessarily value-laden. Thus, the teaching goal is to develop in the child positive values of care, concern, cooperation and sharing in relation to people and the environment. At the end of the programme, it is hoped children will have internalized the concept that each person is a custodian or steward of whatever has been given for his or her use - one's body, personal possessions and all the other living and non-living components of the environment. It should be obvious to children by the time they enter high school that everything in the environment is interconnected and that one's survival depends on how well one helps to maintain the quality of the air one breathes, the water one drinks, and the food one eats. The child must realize that the consideration, concern and care one exercises personally, and for others, and for the surroundings will ultimately redound to everybody's benefit. As part of the environment each individual's activities will either increase chances of survival or lead to destruction.

The programme envisions a child who abhors drugs and dislikes junk food because he or she values the wonderful system that is his or her body. Each sustains and maintains the land and the waterways, the major source of food and the home of many living creatures. Each disposes waste in a manner that can even enhance the environment. Each does not practise nor condone illegal logging which causes destructive floods, destruction of marine resources and depletion of the nation's water supply. Each individual instead initiates, supports or cooperates in activities that help conserve the environment and the living creatures in it.

Various curriculum materials for secondary biology show similar patterns of development. The most recent textbooks were developed based on the Desired Learning Competencies specified by the Department of Education and Sports. They present biology as a study that involves scientific processes and a search for an explanation of biological phenomena in humankind's daily life. Biology is no longer a mere compilation of facts and data.

Current curriculum materials discuss positive attitudes and values essential in any scientific undertaking. Eminent scientists in the country including their significant contributions to the biological sciences are presented to inspire the learners to emulate their dedication and commitment for the improvement of the quality of life of Philippine society.

The thrust of the new curricula is the integration of science, technology, society (STS) nature of biology. (Before the 1960s biology, along with the other science disciplines, was taught as a body of knowledge.) This new orientation searches for answers to questions, or solutions to problems, using the process skills. Knowledge or information about living things and the process skills are used as tools or vehicles for addressing the needs and concerns of society. This requires integration of attitudes and values in the study of biology.

In the course, students are asked to identify and describe steps involved in scientific inquiry or investigation of a given problem or situation. Then they design an experiment to solve the problem. They analyze the components of a scientific investigation or inquiry. They look for innovative solutions, find creative and ingenious answers to problems.

Students also study actual experiments done by scientists which illustrate the continuous quest for satisfying the needs of humankind (for example, to bring down the cost of feed for Mallard duckling which are a source of livelihood for many families, preparing SCP to supplement animal protein).

Students comment on the moral and social issues raised in the textbook regarding the dumping of products such as pesticides, fertilizers and expired medicines, in Third World countries like the Philippines by industrialized countries. They analyze the veracity of claims that pesticide residues in vegetables and fruits in the market are still within tolerable limits by applying concepts of food chain and non-excretability of pesticides.

Biological problems are discussed to develop ecological concern in students. They encourage students to come up with suggestions to conserve the environment. They study situations which demonstrate that ecosystems are open and interdependent such that a disturbance in one creates an imbalance in another. They gather data on the extent of forest destruction in the country, extensive logging and "kaingin" which have brought about serious damage to the forest, and the other ways by which humans destroy the ecosystem. They discuss destruction of mangrove ecosystems as a result of their conversion to fishponds and of deforestation.

Students give their opinion on RLS (Real Life Situations) such as the proliferation of prawn farming in the country: is it a boon or a bane? They study that forest destruction occurring in upland areas, although far from oceans and seas, also damages the coral reefs and mangrove swamps. It adversely affects the economic conditions of small-scale fishermen in the coastal areas. They are invited to propose measures for conserving coral reefs which are being destroyed by siltation.

They analyze, discuss managed ecosystems like a ricefield and a fishpen and realize the need for greater inputs (of fertilizer, pesticides, feeds) in these artificial ecosystems to achieve greater productivity. They infer consequent stress of such managed ecosystems to the environment.

Different methods of teaching are currently used. These serve to reinforce each other and thereby increase student achievement. Some of these methods expose the learner to hands-on as well as vicarious experiences. Thus there are laboratory activities, demonstrations, field studies, interviewing resource persons in the community, group reading of text material, lectures, reporting on an activity or experiment, class discussion of science current events, debating, role playing and viewing films or filmstrips. Activities are classified either as necessary (recommended for all students) or optional or independent (suitable for advanced or supplemental study). The latter are activities that extend over a long time, such as a semester or school year.

Students also undertake relatively simple research which forms part of the school's exhibits at science fairs or for entries to competitions at district, regional and national levels. Most research focuses on technology that has direct utilitarian value to the community.

4.5 Science, Technology and Society

There are now objectives which were not prominently specified about thirty years ago. These relate to technology, societal issues and values. It is now the view that a knowledge-oriented teacher-controlled curriculum is no longer adequate. Students live in a world culture where they compete economically at a global level. Yet all must learn that cooperation is more important than competition.

A United Nations Report of 1985 categorizes population, food, the loss of species and genetic resources, energy, industry and human settlements, global warming and waste as global problems.

Human survival requires better understanding of humankind's relationship to other organisms and the environment. Hunger and undernourishment have not been eliminated in spite of programmes to increase food supply and to control population growth.

The present environment is characterized by a rapid growth of science and technology. The prospects of genetic engineering and the development of numerous technologies have both positive and negative effects on humankind and the environment. Confronted with these controversial issues and concerns, people have to make decisions not only on science and technology but also on its social social aspects and values relevant to their survival as a species.

Conventional school syllabi tend to shy away from the social aspects of science where scientists are not able to provide definitive answers. As a result, attitudes regarding science-related issues are often shaped by information absorbed at home, from mass media or from other incidental sources. Although this information may be inaccurate at times, incomplete or even incorrect, people accept what they hear without experiencing full knowledge of it.

People (as a society) are quite unable to distinguish between sense and nonsense when it comes to science. Even educated, intelligent and learned individuals are unable to consistently bring informed judgement to bear on questions connected to science and technology. These questions are often vital to the welfare of individuals and society and consequently to the future of the world (8).

What kind of education then must be provided to the future adults of this world? The answer is: every individual must develop problem-solving skills that they can use later in life when making policies, forming opinions or making decisions.

Hunt (9) cites that the general aims which introduce advanced course in UK schools and colleges suggest that students should be made aware that biology is not to be studied in isolation. It should be related in the widest sense to the needs of people. Relevant and important aspects of modern life should be stressed. This should include an appreciation of the impact of biotechnology, the fate of human beings in the biosphere and their effects upon it. He adds that in practice, the emphasis in examination papers on theoretical problems means that little or no credit is given for STS issues. This practice promotes the superficial discussion of STS in the classroom. There is little time in crowded syllabuses for the types of classroom activities generally considered appropriate for tackling STS issues.

In this direction, the Science and Technology in Society (SATIS) 14-19 Project in England and Wales produces a low-cost and flexible bank of resources drawing in the interest and enthusiasm of innovative science teachers. These resources are for the general education of all students across a wide ability range. Other materials are available to enrich specialist science education in academic and vocational programmes. Hunt feels that this project will influence syllabus development in the future.

The problems and issues that confront the world today may well be the vehicle for teaching/learning basic concepts, processes and skills. Many of these issues are biological in nature.

Biology education can provide the experiences to develop critical thinking. A good problem-solver and decision-maker has well-developed critical thinking skills. Thus, the development of these skills must be given proper attention in planning and not regarded as something peripheral.

Students must also be given as well the opportunity to exercise and develop creative thinking skills. This involves originality in thinking and the use of more spontaneous and less stereotyped solutions to a variety of problems.

Sharpes (10) proposes that the premise for general education should begin with the notion that what is known today will likely be discarded tomorrow because that is the hard lesson of human knowledge - that we aren't even close to having it right at all. He further argues that "the discipline doctrine of curriculum had no corresponding line of inquiry into social dilemmas, personal or moral problems, as it did for structured domains of knowledge". He suggests that the curriculum must have a fall-back position, something for coping with student affective processes.

Likewise, Gonzales (11) observes that the discipline-oriented curriculum which makes knowledge acquisition an educational priority has skewed school learning toward the cognitive domain. This was and still is, quite comfortable for both teachers and learners since there is a specific content to be acquired (generally facts and information that make up the discipline). Teachers are warned that mere acquisition of knowledge by the students from a prepared list of content may not necessarily be useful in their everyday lives. Classroom activities, therefore, need not be geared only to intellectual development but also to experiences which reflect actual life situations.

Gonzales further points out that education is also not mere development and practice of processes and skills. The total person is not just mind and hands, but also heart. Hence, education must include this part of the individual which can feel and put value on events, people and things in the environment. Teachers are reminded not only to be aware, not only to implement course outlines and syllabi that enumerate content and skills, but also to be explicit in what has mostly been integrated as concomitant learning - the affective dimension. Classroom activities and learning outside the formal classroom should, therefore, make provisions for cognitive, manipulative and affective development. These are intended to help the learner grow and develop as a total person.

4.6 Biology in an Integrated/Multidisciplinary Curriculum

Biology is linked with other natural sciences. It merges imperceptibly with the social sciences. It interacts with psychology, philosophy and ethics. Biology can be instrumental in achieving socio-cultural change by developing in the youth attitudes that would prevent social conflicts.

In a recent planning workshop of the University of the Philippines Institute for Science and Mathematics Education Development (UPISMED) (12) it was discussed that the science curricula for the decade of the 1990s should follow a multidisciplinary approach "... when dealing with issues and applications it is necessary to cross the conventional curriculum barriers between (a) the separate sciences; (b) the sciences and technology; and (c) sciences/technology and the humanities" (Hernandez and Baltazar, 1985).

Figure 4.1 shows the different aspects of this approach in the teaching/learning of biological and physical sciences in the context of the psycho-social environment of the learner. Student materials as well as instruction at pre-service and in-service are to focus on these aspects.

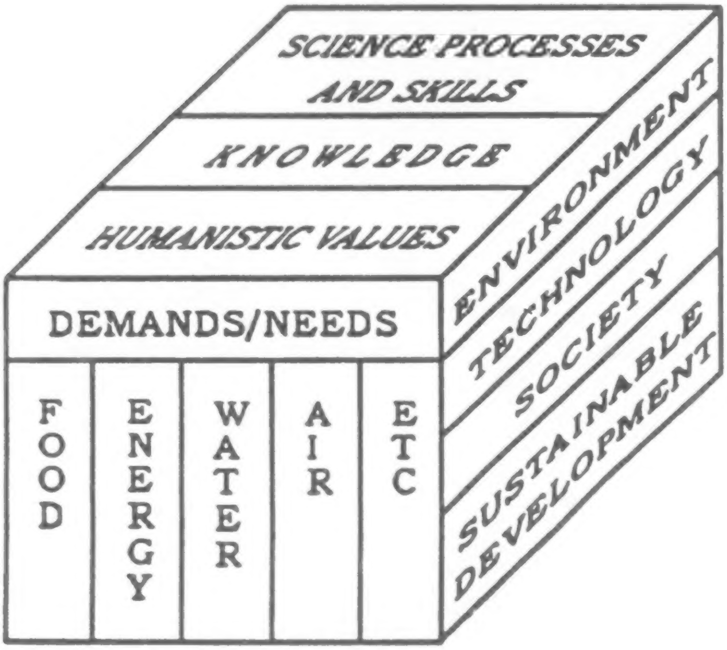
SCIENCE PROCESSES AND SKILLS
KNOWLEDGE
HUMANISTIC VALUES
DEMANDS/NEEDS
FOOD
ENERGY
WATER
AIR
ETC
ENVIRONMENT
TECHNOLOGY
SOCIETY
SUSTAINABLE DEVELOPMENT

Figure 4.1. A model for a multidisciplinary approach to STS education.

At the primary level, an appropriate curriculum is needs-based, as adapted to the needs of the child. At the secondary level, focus is on the environment as the provider of the pupil's needs. Thus it is an environment-based curriculum.

Phenomenologists point out that the excellent starting point of meaningful learning is the learner's personal world. This world is defined by factors in the environment that directly affect them (13).

The pupil should be made aware of his or her needs to survive. It is the environment that provides the learner with materials to survive.

Technology when properly applied spurs economic development which enhances the quality of people's lives. This should be part of the education concerns. Similarly, science curricula should build on the idea of sustainable development. Technological and economic activities for meeting human demands and needs must be analyzed in terms of their impact on society and the environment.

People's needs and demands will be the themes of the curriculum. Learning about these needs draws on concepts from the biological and physical sciences. For example, the theme on ENERGY as a human need brings out the aspects of uses (for example, lighting, heating, transport) and sources (for example, biofuels from biomass). Biology teaching can focus on the microbial conversion of biomass to biofuels - ethanol, methanol, methane gas.

Action taken by policy makers and other members of society are necessarily value-laden. Science curricula should be anchored in humanistic values. They should reflect the ideal of what is good for humankind.

A country's development objectives and humanistic values should underpin curriculum development programmes. These should also pervade in the pursuit of science and technology. Curriculum development plans should dovetail with the national concerns for productivity, self-reliance, improvement of the quality of life, sustainable economic growth and total human development. In the words of Labor PM Callaghan as cited by Tulasiewicz "there is no virtue in having socially well adjusted members of society who are unemployed because they do not have the skills" (14).

Student materials will have an eclectic format where core modules constitute the required content. Other modules will be supplementary for enrichment purposes.

Hence, the curricula for the 1990s will have the following characteristics:

- Research-based
- Learner-centred
- Socially-oriented
- Consistent with the psychological development of the learner

- Multi-disciplinary
- Activity-oriented, inclusive of development of science processes, thinking skills and values
- Enterprise-competence oriented
- Interactive

Materials for learning and instruction will be multi-media using print and non-print. There will be a greater use of non-print materials such as computer software, VTR lessons and films in classroom instruction.

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Chapter 5

SELECTION OF CURRICULUM THEMES AND STRUCTURES FOR GENERAL EDUCATION

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5.1 The Problem

Paul Kurtz (1) summarises the purpose of a sound general education in the following terms: "The goal of education should be to develop reflective persons - skeptical, yet receptive to new ideas; always willing to examine new departures of thought, yet insisting that they be tested before they are accepted".

For William Mayer (2) this view of general education placed science in centre stage. He believed that there is a great need for better instruction about science in the general education of all citizens. This view implies that a basic component of general education should include two aspects of science. According to J. Patrick (3) these are:

i) knowledge of connections between science and society, in particular skills in making, judging and influencing decisions about science-related social issues.

ii) appreciation of the methods of inquiry and of the socio-political attitudes necessary for sustaining the scientific enterprise.

Biology, as part of general education, faces some difficulty in reconciling the needs of the discipline and the needs of general education. In the past school biology has undergone great changes from a subject centred on descriptive classification, comparative anatomy and life cycles to an experimental science with strong leanings towards biochemistry, physiology and ecology. In addition greater emphasis is given to biologically based social problems such as pollution, population and conservation (4). Such developments tended to make biology a "fractured" discipline dealing with a number of fields. This tends to prevent biology from being viewed as a coherent discipline as are other school science subjects such as chemistry and physics (5).

The growth of biological knowledge and the constant state of such growth has further increased the number of fields of biology and we must now add areas such as biotechnology, bioethics, biophysics and so on. As more and more topics appear they compete for space and time in the school curriculum. Curriculum designers are faced not just with the difficult task of adding to an already overcrowded biology curriculum, but rather of thinking in terms of replacing some or all of the content of the past with content of the present and future. Hence there is a critical need for judicial selection due to the exponential increase in biological knowledge. The central problem therefore, is to determine suitable criteria for selection.

The problem is made less difficult, however, if a broader view is taken of what is meant by "general education". A.N. Whitehead in his famous discourse on the aims of education (6) stated that there is "no royal road to learning through an airy path of brilliant generalizations. There is a proverb about the difficulty of seeing the wood because of the trees. ... The problem of education is to make the pupil see the wood by means of the trees". And, "the solution which I'm urging, is to eradicate the fatal disconnection of subjects which kills the vitality of our modern curriculum. There is only one subject-matter for education, and that is Life in all its manifestations" (7). Whitehead goes on to argue that "the essence of education is that it be religious" and explains this concept with the comment that "A religious education is an education which inculcates duty and reverence. Duty arises from our potential control over the course of events .. And the foundation of reverence is this perception, that the present holds within itself the complete sum of existence, backwards and forwards, that whole amplitude of time, which is eternity" (8).

With broad guidelines such as those proposed by thinkers such as Paul Kurtz, J. Patrick and A.N. Whitehead it is possible to derive practicable criteria for the selection of content which will contribute to general education.

5.2 Criteria for Selecting Content for the Biology Curriculum

Biology curriculum designers of the nineteenth century had little difficulty in their mission because the content of biology was basically morphological and systematic in nature. The identification and structure of organisms formed the central core of knowledge which was taught not so much for its intrinsic benefit to the learner, but rather because it was practically the entire sum of biological knowledge of the day. But the situation is very different today and the following central questions need to be addressed before suitable selection criteria can be established:

i) What is basic biology?

ii) What are the unifying themes and principles which provide the framework of biology?

iii) What are the unique skills which contribute to making biology a scientific discipline?

iv) What are the limitations on the effective implementation of the curriculum?

In the light of these questions and considering the previous deliberations about the goals and advocacy for general education (section 5.1) the following guidelines are proposed for the design of an effective, relevant school biology curriculum.

First. The structure of the curriculum should be flexible so as to anticipate change. A clear distinction, however, should be made between conservative topics which are relatively unchanging, and ephemeral topics which represent the changing elements (9).. The curriculum should be viewed not as an "entombment of knowledge, but rather a structure wherein knowledge is communicated and used" (10).

Second. Biological literacy should be taken into consideration. This means that the curriculum should help individuals develop a basic knowledge of biological vocabulary, methodology, and an understanding of the impact of science on the world (11). This would also satisfy the requirement advocated by W. Mayer of biology as an exemplar of science (12).

Third. The curriculum design should be essentially future-oriented, as the world for which the students must be prepared is not the world of today, but the world of the next fifty years (13). The following aspects are listed as exemplars of a future orientation.

i) Human biology is an area which meets future expectations since, according to Paul Hurd, it aims to develop the enlightenment that will make it safer for human beings to direct their own evolution and shape the course of civilizations (14). This area is also consonant with the interests of students who particularly want a biological education which teaches them about themselves, helps them understand other people, and considers ways for improving the quality of life (15).

ii) Health education should be part of the content of the curriculum because it is a vital component of preventive medicine. Through appropriate health education each individual can be encouraged to fully take on the responsibility of keeping healthy (16).

iii) Biotechnology should be included as it is having and will continue to have a vital impact on our personal lives as well as on social and economic matters (17).

iv) Aspects of education for leisure should be addressed by the biology curriculum as automation resulting from computerization and other technologies affects the balance of peoples' lives and leads to more time for leisure activities (18).

v) Biosocial issues arising from interaction between science, technology and society should be identified and analyzed. The aim should be to help students make more informed decisions about such issues and enable them to evaluate future controversies.

Taking these determinants into consideration, and recognizing that in absolute terms no knowledge in itself is bad or valueless, it is reasonable to suggest that the choice of content for a meaningful and effective school biology programme, should take into consideration that knowledge which will be of value in the twenty-first century. Thus the following criteria might serve to direct the attention of curriculum developers away from the inclusion of prosaic materials which are there only because they have always been included in the past (19) - See box below.

TEN CRITERIA FOR THE SELECTION OF CONTENT FOR AN EFFECTIVE SCHOOL BIOLOGY CURRICULUM

Criterion 1. The content should be accurate in the sense that it is a reflection of experiment and observation, and has been tested and accepted by the scientific community.

Criterion 2. The content should be an illumination of the processes of science, in the sense that it reflects experiment and observation, and repetition. It should also enable a student to gain an understanding of how science operates from consideration of a given point of content.

Criterion 3. The content should be contributory, that is it should have a value in the lives of students, and have some applications to their future.

Criterion 4. The content should include basic knowledge, which provides a foundation for the comprehension of a variety of problems. Such knowledge has more than one use. For example a knowledge of DNA structure is pervasive throughout the organic world, while the parts of a flower or the names of the human wristbones, are more specific.

Criterion 5. The content should be necessary in the sense that it is used for the comprehension of additional information. The necessity of content depends on the place in which students live. Thus, the knowledge of insect borne diseases is necessary in areas where such diseases are major scourges.

Criterion 6. The content selected should support concepts, as concepts are more important than individual facts. This is because concepts and not facts have a predictive value which directs the biology discipline. Diversity, adaptation, and continuity are concepts in themselves, but are themselves synthesized and related by the theory of evolution. They thus have a key conceptual role.

Criterion 7. The content should be appropriate for the students at the grade level to which the curriculum is directed. The age, background and degree of intellectual maturity of the students must be taken into account in order that students can benefit from comprehensible materials on which they can build at a later age.

Criterion 8. The content should present some challenge to the student either through its own intrinsic contribution or in revealing or explicating related data. Isolated knowledge with no relevance either to the student or within the discipline tends to be merely an intellectual hurdle rather than an intellectual challenge.

Criterion 9. The content should demand analysis, synthesis or evaluation. Such knowledge can be considered active rather than passive. The student should interact with the material rather than merely serving as a passive receptor. Such a type of knowledge is meaningful, credible and contributory.

Criterion 10. The content should demand critical thinking. A statement such as "Human populations are outstripping the planet's resources" makes students exercise the critical facility that lies dormant in many.

5.3 A Review of the Criteria

The criteria suggested above (section 5.2) for selecting content for the biology curriculum emerge from an analysis of major trends traced in recent literature world-wide. The criteria may be grouped in the following categories:

i) Relevance

Biology teaching should be relevant to the needs of students, society and the discipline. The curriculum is considered relevant by "the extent to which it is related to the total environment in which a student lives and the help it provides in achieving adjustment to that environment" (20).

ii) Objectives

Objectives of the biology curriculum reflect a "values approach", which brings together knowledge, understanding attitudes, skills and insights in an attempt to understand societal values and to resolve conflicts between values (21). Thus, objectives of the biology curriculum reflect a true confluence between cognitive and affective elements, or an integration of affective, ethical, and aesthetic understanding of biological concepts with individual cognitive and affective development (22).

Moreover, biology education is placing fundamental concepts in a socially relevant and personally meaningful context for students (23). It meshes the strands of scientific knowledge, a person's individual and community needs, and a consideration of moral values, into a firm educational fabric (24).

iii) Subject areas

Subject areas are selected (or should be selected) in the light of the relevance orientation and the types of objectives referred to above. However, this does not mean abandoning the teaching of facts, but the facts chosen should not be an end in themselves. There is still an important place for scientific and descriptive approaches in the biology curriculum. But, since biology education is now advocated for improving the quality of life, so human biology and biological topics of social implications, such as health, population, genetics, environment, nutrition, biotechnology, and so on should be emphasised. Thus, biological knowledge can be used to enhance understanding of oneself and to benefit the quality of life for human beings (25). That, in essence, necessitates an emphasis in subject matter on issue studies rather than knowledge studies, since issue studies link biology with the realities of people's lives (26).

iv) Contributions of the biology curriculum

Since the curriculum should be directed to preserving and improving the quality of life and living, so interdisciplinary, cross disciplinary, multidisciplinary and transdisciplinary ideas should be emphasized in the content of the curriculum. Hence, the curriculum should assimilate contributions to fields such as agriculture, health, nutrition, consumer awareness, sex, environment, population, career awareness and religion. Thus, an informed citizen would emerge who could make sound decisions about biologically-based problems that might appear in his/her personal and professional life.

v) Levels of biological organization

With advancement of the science of biological science, it is necessary to go beyond the systematics and morphology approaches of the past. Cells and their molecular functioning are introduced to students, and in the opposite direction living organisms are studied in their populations and communities. Seven levels of biological organization are widely used in approaching the content of biology curriculum. These levels are, the Molecular level, the Cellular level, the Organ and Tissues level, the Organismic level, the Population level, the Community level, and the World Biome level.

vi) Social issues in biology curriculum

The tradition has been to keep the biology curriculum separate from analysis of those social issues, controversial ones in particular, which arise from the interaction of biological knowledge and society. Biology, however, is not neutral or socially sterile. In this sense biology-based social issues have to be identified and analysed in a fair and considering way. Students are not served by biological knowledge if they are not involved in the evaluation of issues such as genetic counselling, birth control, drug abuse, transplantation of organs, genetic engineering, sex selection, human races, sperm banks, human cloning, surrogate motherhood, transfusion of blood, or human inbreeding. Moreover, social issues provide unifying themes and organizers for the curriculum (27). They make science more subject to manipulation and persuasion (28).

The biology curriculum should train students to consciously appraise the moral implications of biological knowledge in order to be able to make appropriate decisions at either personal or societal levels. It, also, should match biological achievement with corresponding implications for personal and social living (29).

5.4 The Criteria and Basic Education

It is worthwhile to note at this point that the criteria for selecting content, and the major features of biology curriculum outlined above, relate to the following dimensions of basic education.

- Individual needs and concerns, such as health, nutrition and sex.
- Community needs and concerns, such as health, food, moral values, career awareness, and consumer awareness.
- National needs, including agriculture, population, environment, religion and health.

- International issues: pollution, population, conservation of natural resources, energy, alternative resources and urbanization.
- Biology teaching and the quality of life. The major shift in thinking about biology education outlined above (sections 5.2 and 5.3) represent a contribution by biological knowledge to improving the quality of life.

Thus both materialistic and non-materialistic elements of life, such as safety, housing, food, health, security (materialistic), and love, freedom, happiness and aesthetics (non-materialistic) are dealt with (30). It is clear, therefore, that contemporary trends in biology education are consistent with the requirements of basic education. This goes some way to validating the trends in terms of the broad aims of education.

5.5 Factors Influencing the Selection of Content

It is pleasing that the rapid developments and advances of biology education are directed to understanding human beings and their behaviour, and to promoting a favourable direction for social and cultural change. All this represents the bright side of biology teaching, as the subject matter must always have scientific, technological, social and personal validity.

In spite of these very positive aspects, a group of factors should be attended to in order for the design and implementation of the curriculum to proceed smoothly. These factors can be grouped into five categories, i.e. external, internal, pupils, resources and cultural.

The external factors include: the number of courses provided besides biology, the system of examinations, the types of questions used in examinations, the university admission requirements, the role of inspectors and supervisors, and the incentives for the teaching profession.

The internal factors include: qualifications and experience of teachers, methods used in teaching biology, mathematical, chemical and physics concepts used in biology, the type of school administration, the type and amount of homework required, and the load of biology teaching per week.

The pupils' factors include: class size, degree of interest in learning biology, discipline in classes, abilities of pupils, the co-operation of pupils, background of pupils in other sciences, and the proficiency of pupils in the language of instruction.

The resource factors constraining or facilitating biology education include: laboratories and facilities, the amount of time allocated for biology in the time-table, time allocated for field trips and visits, reference books available in the school library, clerical help for teachers, laboratory assistance available for teachers, and the in-service training programmes available for teachers.

The two main cultural factors which influence the design and implementation of the biology curriculum are (i) beliefs and mores on issues of morality and (ii) religious beliefs. An effective curriculum, therefore, should take cognizance of cultural differences in regard to these aspects, not only from country to country but for contrasted groups within a country.

Thus, the content of the biology curriculum must be selected in light of: quantity and quality of teachers; time available for biology teaching in the time-table; school facilities; administrative structures; fiscal issues; learning resources; and community attitudes, values and expectations (31).

5.6 Relating Content to Curriculum Structure

In the recent literature there appears to be a consensus that biological education should be broad and scientific while emphasizing humankind and our social and natural environment (32). This means that the goal of biology is to bring science into harmony with society. Hence, students are helped to lead more meaningful, satisfying and responsible lives, both personally and socially (33).

Such recent consensus on aims and objectives of biology education highlight a trend towards orienting the biology curriculum for general education. The following points aim to shed light on such a trend.

i) The biology curriculum should emphasize the humanistic nature of biological sciences. It should be stressed that biology is the product of humankind resulting from an attempt to manage and control nature (34).

ii) Biology has become more inter-disciplinary and citizenship oriented (35).

iii) Biology is distinguished from other sciences for its value to the individual and by its democratic goal of understanding humankind (36).

iv) The formulation of a biosocial synthesis in the biology curriculum gives it credibility and a rightful place in general education (37); thus a widespread scientific literacy would be achieved (38).

v) The hope lies in a public educated about the meanings and limits of science and in the use and limitations of technology; in scientists better educated to understand the relationship between science and technology on the one hand and ethics and politics on the other; in human beings who are as wise in the latter as they are clever in the former (39).

vi) The biology curriculum should aim to enable students use both the knowledge and products of science in their thinking, their lives, and their work. Students should be able, also, to take informed choices regarding their health and lifestyles based on evidence and reasonable personal preferences, after taking into consideration the short- and long-term risks and benefits of different decisions (40).

In light of these deliberations, specific criteria for relating content and structure in the biology curriculum should be emphasized. These are listed in the box below.

CRITERIA FOR RELATING CONTENT AND STRUCTURE IN THE BIOLOGY CURRICULUM

Criterion 1. The requirements of students, and the needs of society must be fulfilled, but without sacrificing a sound fundamental biological knowledge. Thus, an appropriate blend of knowledge and issue studies is ensured, the latter linking knowledge with the world in which students live (41).

Criterion 2. The biology curriculum should be constructed within a core science framework which provides a sound foundation in biological principles and which at the same time engages the interest of a majority of students because they relate to real life (42).

Criterion 3. The content in a biology curriculum should include a genuine biosocial synthesis that recognizes the importance of biology as a scientific discipline and which relates this science to the life of the individual within the family, at work, and in recreation and to society in terms of communal, national and global issues (43).

Criterion 4. The biological knowledge included in the curriculum should be structured to reflect the integration, sequence and continuity of biological concepts (44).

Criterion 5. The content should be arranged in relevant and appropriate ways, such as: levels of biological organization, social themes, human-centred principles, ecological approaches and so on, as outlined in Chapter 2.

Criterion 6. The content should be linked, whenever necessary and appropriate, to other school subjects, such as chemistry, physics, mathematics, social sciences and religious education.

The above criteria for relating content and structure of the biology curriculum would be appropriate for any curriculum pattern chosen for general education. However, curriculum patterns are decided in relation to: the ladder of education, time allocated for biology in the timetable, fiscal, natural and human resources available for biology teaching and cultural factors (45). But, there is no escape from including biology in the general education of all students at all levels. An integrated pattern of curriculum linking together all subjects is appropriate for children K-4; an integrated science approach would be appropriate for children in grades 5-8; human biology and ecology would be needed for students in grades 9-10; and integrated biology would be appropriate for students in grades 11-12 and as a university introductory course.

In conclusion, the global structure of the biology curriculum should emphasize the major theme that "Humankind shares with other organisms one balanced environment; we affect all its components, and we are affected by them". This major theme includes the following sub-themes:

i) diversity and unity and their origins

ii) the unique role of humankind in nature is accomplished through our biologically and psychologically integrated human body

iii) lives of organisms are maintained through regulation and homeostasis.

If curriculum designers keep those broad themes in mind, school biology programmes are likely to satisfy both the needs of the discipline and the aims of general education.

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PART II

STRATEGIES AND METHODS IN THE TEACHING OF BIOLOGY FOR GENERAL EDUCATION

Introduction to Part II

If secondary school biology is to meet the needs of general education as well as the classical needs of the discipline the content needs to focus more on socially relevant issues. In addition the methods of teaching need to be broadened to include approaches which were once the concerns only of the social sciences. Assessment methods and types of test items also need to reflect these changes.

Part II reviews selected areas of content appropriate for this reorientation. In the first place (Chapter 6) biological content which focuses on immediate personal needs is examined. This area includes topics such as shelter, food, health and hygiene. In the second place (Chapter 7) areas related to the immediate needs of the community are discussed. These include environmental matters, population issues, family life, work and vocation, use of leisure and also equal opportunity and equity issues. In the third place socially relevant topics with a greater future orientation are discussed in Chapter 8. Topics covered in Chapter 8 include scientific literacy, resource management, the management of change, the determination of science policy, peace studies and the quality of life.

Each topic such as "shelter", "food", "family life", "resource management", "peace studies" and so on is presented under three headings: (i) rationale and place in the biology curriculum; (ii) an example or examples of content or of a teaching episode with an emphasis on participatory activity by learners and; (iii) some examples of possible projects, assessment activities, and test items.

Wherever possible the examples selected are from curriculum guides, textbooks and other resource materials reviewed by the author in the world-wide survey conducted 1988-1990 and discussed in Chapter 2. Material from a broad range of school systems from many countries has been chosen to emphasise that the reorientation towards societal relevance is a world-wide phenomenon. Where appropriate examples are not immediately to hand the author has supplied brief notes and guidelines suggesting a possible approach. The sources of examples from specific textbooks and curriculum guides are acknowledged. Any examples not so acknowledged are by the author.

Chapter 6

MEETING IMMEDIATE PERSONAL NEEDS

6.1 Introduction

By "need" psychologists generally mean a lack or a deficiency in an individual. The existence of a need implies a search to satisfy the need and this can be thought of as seeking to achieve a goal. Several schemes have been proposed to classify needs. One of the most widely used by psychologists is the system proposed by Henry A. Murray in the 1930s. His system identified twenty categories of need as listed below (1).

Abasement
Achievement
Affiliation
Aggression
Autonomy
Counteractions
Defendance
Deference
Dominance
Exhibition
Harmavoidance
Infavoidance
Nurturance
Order
Play
Reflection
Sentience
Sex
Succorance
Understanding

Many well known personality tests such as the widely used Thematic Apperception Test (TAT) are based on the Murray scheme.

A second useful example of a needs classification was provided in 1963 by Louis Raths and Anna Burrell (2). They proposed eight categories of need as follows:

Belonging
Achievement
Economic Security
Freedom from Fear
Love and Affection
Freedom from intense feelings of guilt
Sharing and self-respect
Understanding

Biology educators are probably most familiar with the system advocated by Abraham H. Maslow in 1970 (3). Maslow proposes a hierarchical set of six needs:

1. Physiological
2. Safety
3. Love and belonging
4. Self esteem
5. Self actualization
6. Desire to know and understand

Maslow claims that the lower physiological and safety needs must be satisfied before the higher needs can be met.

The issue of "needs" is therefore complex and there is little agreement between psychologists about how to designate or classify them. Nevertheless some understanding of human needs is necessary if school biology curricula are to be truly relevant to the genuine requirements of individuals and of society as a whole. Therefore since 1988 the Education Commission of the International Union of Biological Sciences (IUBS-CBE) has been conducting empirical cross cultural studies of human needs and has been trying to relate these studies to the teaching of biology (4).

Preliminary results of the IUBS-CBE studies show human needs to be (i) wide-ranging and diverse; (ii) mostly based in biology or related to biological phenomena and (iii) to have different priorities in different cultures. The cultural determinism aspect is especially important for curriculum workers who must understand that needs at the physiological or safety levels of the Maslow hierarchy, for example, may be very significant to cultures under threat of famine or warfare whereas higher order needs may dominate in a more affluent and secure society.

Because of these complexities and uncertainties about the fundamental nature and classification of human needs the present author has taken a pragmatic approach. Only those categories of need which have an obvious and direct basis in biology or link with biology and which are at present treated or could easily be treated in present school curricula have been selected for discussion below. They do not conform to any given system of classification but can be readily related to the Murray, Raths and Burrell or Maslow systems, and especially to the Maslow approach.

6.2 The Need for Shelter

i) Rationale

Biological aspects of "shelter" can be considered in several ways. One of the more traditional approaches is to review how humankind has utilized biological resources to construct houses and other forms of shelter. Sources of materials from the living world such as timbers, vines, leaves, skins and so on can be identified and uses described. This approach can be especially significant if it is linked to the traditional technologies of a given culture.

Another approach is to compare shelters made by a variety of animals with houses constructed by humans. Animal shelters could include (i) the nests and hives of insects - especially colonial insects such as ants, bees and termites (ii) the nests and bowers of birds (iii) shelters constructed or utilized by aquatic organisms (iv) burrows, dens and other types of shelters utilized by reptiles and mammals and so on. Comparisons with human housing could be in terms of protection from weather and predators; establishment of a congenial microclimate; a secure place for breeding and raising offspring; a base for exploring and utilizing the resources of the local environment or microhabitat; a place for storage and processing food and other resources; and a system of organizing cooperative living between members of a family, colony or community.

A further approach would be to examine shelter and housing from the point of view of human evolution. This could explain the early use of natural shelters such as caves as "dens" and the gradual evolution of the modern built environment including the sophisticated artificial environments of high rise apartments in modern cities and the artificial environments of space craft and space stations. Totally "closed" systems such as space ships or space stations could be examined from the point of view of community ecology, biogeochemical cycles and physiological adaptations.

Studies of housing can also be approached from the viewpoint of human ecology. Types of housing in different parts of the world and in different cultures could be compared in terms of environmental adaptations - adjustments to climate, to the existence of predators, to the prevalence of natural disasters such as earthquakes, seasonal floods or wind storms and so on.

Another possibility is to examine the health and hygiene aspects of housing. Consideration of issues such as ventilation, lighting, waste disposal, sewage treatment, water supply, food storage and processing, elimination of disease organisms, crowding and so on cpuld provide the framework for a systematic study of home hygiene.

Standards for housing construction can also provide an interesting way of examining the need for shelter from a biological point of view. The number and placing of windows; the type, number and location of toilets; the quality of the water supply; the amount of living space per person; the quality of cooking facilities; the location of the house in regard to services and to environmental hazards and so on all provide an opportunity to examine aspects of human biological need.

ii) Examples of Relevant Content

Example 6.1: Plant materials for traditional technology

School System: Papua New Guinea: Tigak speaking people of the Mainland coastal Kavieng District New Ireland.
Approach: A list of local plants used for traditional housing.
Source: Beney, J.K. "Coastal Subsistence of Mainland Kavieng District" in Science Traditional Technology Teachers Guide Grade 10 Unit 5. Boroko: Papua New Guinea Department of Education 1981. pp 88-111

	Plant	Uses for Housing
1.	English name: Pandanus Botanical name: *Pandanus spp* Pidgin: Marita/Bulume Tigak language: Aum	The leaves, with the midrib removed, are folded over bamboo strips and sewn together side by side. These are used instead of sago leaves to roof houses.
2.	English name: Bamboo Botanical name: *Bambusa spp* Tigak language: Kariu	The uses to which the people put bamboo are numerous and varied. To mention a few: - Fences, - Walls, - Floors, - Roofing, - Water carriers, - Beds - Rat traps - Downpipes and guttering to collect water from the roof.
3.	English name: Pandanus Botanical name: *Pandanus conoideus* Pidgin: Marita/Bulume Tigak language Bune	The leaves are cut into strips and woven into matting.
4.	English name: Pandanus Botanical name: *Pandanus tectorius* Pidgin: Marita Tigak language: Aran	The leaves are used to make matting, as above, and to weave baskets and small hand fans.
5.	English name: Sago palm Botanical name: *Metroxylon sagu* Pidgin: Sak sak Tigak language: Saksak	The midrib is removed from the leaves which are folded over bamboo strips and sewn together side by side. These are then attached to the rafters by cane and allowed to overlap each other to form all-weather roofs. They are also used for walls. The frond is cut into strips (pangal) and used for walling houses. The frond is cut into still finer strips 1-2cm wide and used to weave wicker-work panels which are used as walls for houses or for window shutters.

6. English name: Coconut palm
Botanical name: *Cocos nucifera*
Pidgin: Kokonas
Tigak language: Nik

The leaves, still attached to a narrow strip of the frond are used to weave the following:

- Matting
- Baskets
- Cooking baskets - small baskets used for cooking rice.
- Walling for houses

The trunk is cut up and used as piers under the houses.

The shell of the coconut itself can be cut in half and used as cups, or a small hole can be cut in the top and, after all the flesh has been removed, it can be used as a water container.

The trunk is used for walling houses. This involves immersing the trunk in sea water for a period of about 10 days to remove the bark. The pith is then dried in the sun and is ready for use.

7. English name: Bangalow Palm
Botanical name: *Archontophoenix sp*
Tigak language: Limbum

The trunk is split and used for flooring in houses.
The split trunk is sometimes used for walling houses.

The flower sheath is used to make buckets and baskets.

8. English name: Betel nut
Botanical name: *Areca catechu*
Pidgin: Buai
Tigak language: Bua

The trunk is split and can be used to replace limbum as flooring.
The flower sheath is used to make buckets and baskets.

9. English name: Blady grass
Botanical name: *Imperata cylindrica*
Tigak language: Gi

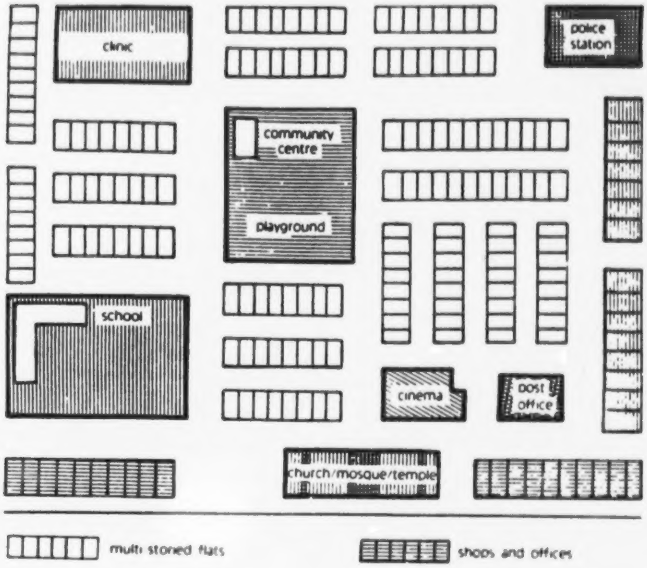
The cut grass is doubled over bamboo strips to form thatch for making all-weather roofs. It is sometimes used in walling also.

Example 6.2: Household siting, standards and hygiene

School System: Singapore secondary school human biology
Approach: Description of hygienic housing using local examples.
Source: Textbook for secondary school "Human and Social Biology" for the School Certificate/General School Certificate Ordinary level - Republic of Singapore: Phoon, W.O., Chew, P.K. and Goh, E.H. Comprehensive Human and Social Biology 3rd edition. Singapore: Federal Publications 1986 pp 265-273 (Selections only)

30.2 The Siting of a House

In many countries, the government has a special planning department which controls and assists in the building development. Often they have a Master Plan in which the whole country is divided into zones, like city centres (for business and commercial activities), industrial areas, residential areas, green belts (for forest reserves or water catchments), or recreational areas.


clinic
police station
community centre
playground
school
cinema
post office
church/mosque/temple
multi storied flats
shops and offices

AN EXAMPLE OF URBAN SITING

Here are some points to bear in mind when choosing a site for a house.

For rural areas, e.g. kampungs, villages or farms, the important points to consider are:

1. **Accessibility**. It should not be too far from the main roads where buses are available to bring people to and from the town.

2. **Nature of soil.** The ground should be suitable to provide a firm foundation for the structure. Houses should be far away from marshes and swamps, as these are favourable breeding grounds for the malaria-carrying mosquito.
3. **Level of ground.** Higher ground is better than low-lying areas, because drainage is easier, and also floods are less likely to occur.
4. **Source of water.** If a piped water supply is not available, then nearness to sources of well water is important.

For urban areas, the important points to consider in addition to the points enumerated for rural houses are:

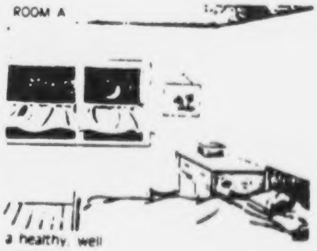
1. **Nearness to community services.** Nearness to public amenities such as schools, markets, shops, banks, post offices, government departments and community centres reduces travelling, and helps daily activities.
2. **Clean and healthy environment.** Factories and workshops in industrial zones produce dust, smoke, fumes, smells and noise during production hours. These pollutants will affect residential zones if they are situated nearby. A house should be located more than 100 metres away from the nearest factory. Housing areas should also have proper drainage and good refuse disposal systems.
3. **Recreational facilities.** Suitable areas for living, include those with large spaces for recreation nearby, e.g. sports fields, swimming pools, public parks, club houses and community centres. These facilities are particularly important for community living in high-rise housing estates, as space within the flats themselves may be very limited.

30.7 Housing Standards

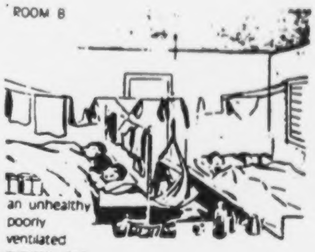
In most countries there are laws called building regulations which ensure that houses are constructed and maintained to comply with certain basic requirements. Among the necessary and desirable requirements deserving attention are the following:

1. Adequate space to avoid overcrowding. The floor area of the bedroom should be greater than 11 m^2. Each person should have about 30 m^3 of living space, although this volume can be reduced slightly if the ventilation is very good.
2. A minimum ceiling height of 3 m.
3. The proper placing and size of window spaces. Windows should always open into an open space and their total combined space area should be at least 15 per cent of the total floor area of the room they serve.
4. An adequate number of toilets in relation to the number of persons living in the house or using the building. Usually, there should be at least one toilet for a family of 10 persons.
5. Proper drainage of the premises.
6. Proper garbage collection, storage and disposal facilities, e.g. rubbish chutes and bin centres.
7. Safe water supplies and storage facilities. Piped and filtered water supplies are best.
8. Adequate lighting of the premises to ensure good visibility and to prevent accidents.
9. Protection from electrical hazards by properly insulated wiring, switches, fuse boxes, and other safety devices.

Most of the requirements are the concern of the local authorities, planners, architects, builders and construction engineers. Before a householder buys a house he should make sure that the conditions are satisfactory, particularly as regards ventilation, lighting, drainage, water supply and sanitary facilities. However, these laws mostly apply only to urban areas. In the rural areas, the standards are seldom imposed.



a healthy, well ventilated room



an unhealthy poorly ventilated overcrowded room

HEALTHY AND UNHEALTHY BEDROOMS

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30.8 Housing and Health

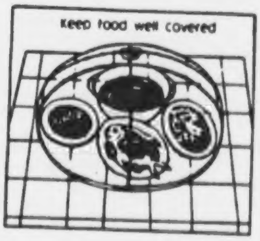
Housing has a close relation to health. In slum areas, it has been found that more people, particularly children, get communicable diseases such as tuberculosis, influenza and skin infections. Some of the factors for this are:

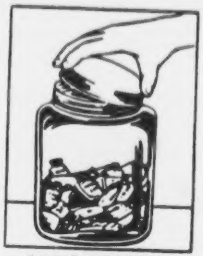
1. **Overcrowding.** When there are too many people living in a cubicle or room, they are physically very close to each other. Such conditions favour the transmission of communicable diseases. For example, if one person has tuberculosis, the bacteria in him are easily spread to others near him through droplets produced by his coughing, sneezing or spitting. Skin infections, e.g. ringworm, can also be transmitted by direct contact.
2. **Poor ventilation.** Inadequate renewal of the air in rooms also favours transmission of diseases because impurities such as micro-organisms and toxic gases may accumulate in the air.
3. **Poor lighting.** Inadequate lighting makes it difficult to see dirt and dust, and so discourages the proper cleaning of rooms.
4. **Poor refuse and sewage disposal facilities.** These give rise to the breeding of flies, rats, cockroaches and other vermin.

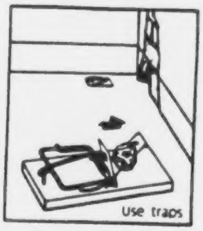
30.9 Hygiene in the House

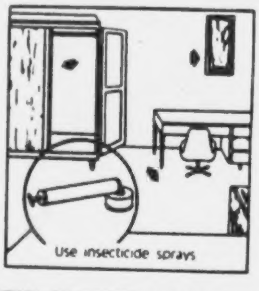
The aim of household hygiene is to eliminate all the conditions favourable to disease-producing organisms and vectors. Some of the points to consider are:

1. **Cleanliness.** It is very important that the house is constantly cleaned. This includes the sweeping and washing of floors, and the dusting of cupboards, furniture and windows. Close attention should be paid to the cleaning of toilets, kitchen sinks, wash areas, and refuse compartments.
2. **Good ventilation.** Whenever there are people in the house, the windows should be open to allow the free flow of fresh air, and to let in sunlight.
3. **Good lighting.** Always have the house adequately lighted as this encourages cleanliness by showing up the dirt and dust. It also prevents accidents caused by the tripping and the stumbling over of unlit objects on the floor.
4. **Control of vermin and insects.** The common household pests are rats, cockroaches, flies and ants. Rat control may be done by rat proofing the house. Rats may enter the house through gaps at the base of doors and windows, the ventilators, and the openings around pipes. Such gaps should be closed with concrete or metal fittings. Other methods of control include traps, rat poisons, and the keeping of cats and dogs, which are the natural enemies of rodents. Cockroaches may be controlled by covering the crevices on walls and kitchen cupboards, screening the gulley traps with fine wire meshes, and applying insecticides. Flies may be controlled by the proper storage and disposal of garbage, and the cleaning of toilets with antiseptics. Ants may be prevented from getting at the food in storage cupboards, by fixing water containers to the legs of food cupboards.




Keep all sweet food in airtight jars





THE CONTROL OF INSECTS AND OTHER PESTS

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iii) Examples of Project and Test Questions

(The following are suggestions by the author.)

- Project. Qualities of good house. Draw a floor plan of your own house or apartment. Show by short descriptive labels
  - (a) the function of each room
  - (b) how the house is ventilated
  - (c) sources of natural and artificial light
  - (d) location of cooking, washing and toilet facilities.

  How could your house or apartment be made an even better place in which to live?

- Project. Shelter made by animals and humankind. Compare an insect colonial hive (bee, ant or termite) with a high-rise apartment block in a large city such as Singapore, Hong Kong or New York. Comment on aspects such as:
  - (a) types of rooms/spaces and their use
  - (b) how the microclimate is controlled
  - (c) how security is provided from outside dangers
  - (d) special provision (if any) for housing and looking after the young (babies)
  - (e) how food is stored and processed
  - (f) how the shelter is kept clean and in good order
  - (g) location in relation to resources needed such as food, water, disposal of wastes and other needs.

  What are the main differences between insect and human shelters?

- Project. Comparative housing. Choose typical rural villages from two contrasted cultures such as East Africa (Masai); northern Japan and Western Samoa. Find out as much as you can from the library about the construction and standard of the houses. Compare the houses by commenting on the following aspects:
  - (a) Building materials used
  - (b) Adaptations to the local environment - climate, predators, potential natural disasters, availability of resources and so on.
  - (c) Number and types of rooms and the average number of people sleeping in one room
  - (d) General layout of the houses
  - (e) Siting of the houses in relation to services.

  Can you explain any differences in the construction and layout of the houses in terms of (a) the characteristics of the local environment and (b) the way of life of the people?

- Test Questions

1) In many tropical countries rural houses are frequently built on stilts. This is to:
   - (a) improve ventilation
   - (b) help protect from pests and vermin
   - (c) keep the house cool
   - (d) all of the above

   (A . d)

2) State which of the following aspects of housing are true (T) or false (F):

(a) Toilets should always be located near the kitchen
(b) Hard woods are generally better than soft woods for building houses
(c) In cold climates it is good for people to crowd together in small rooms
(d) Window openings should generally be opposite each other
(e) Pets such as dogs or cats should generally stay out of the house

(A a = F, b = T, c = F, d = T, e = T)

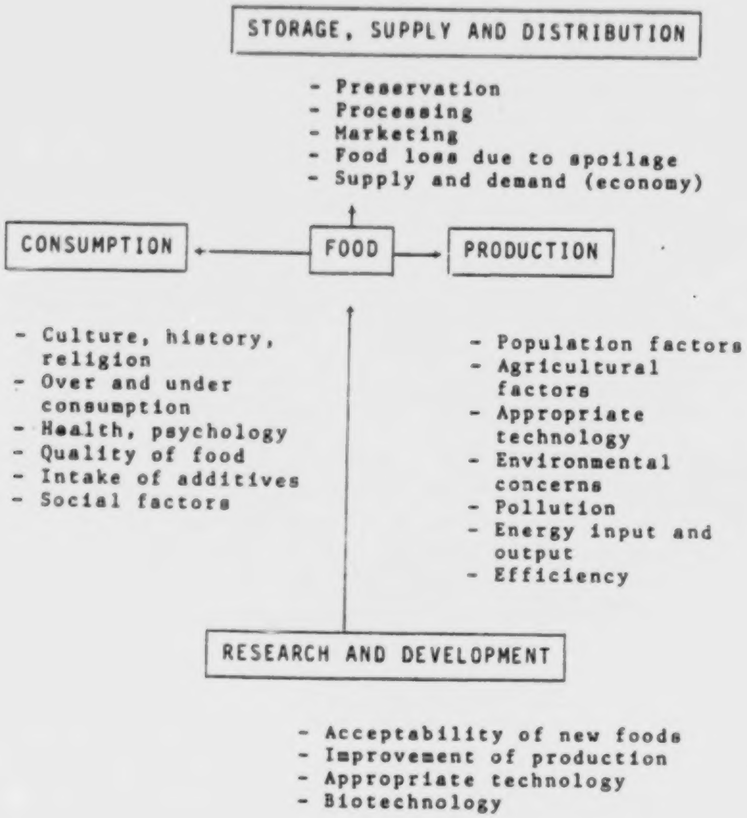
6.3 The Need for Food

i) Rationale

"Food" has almost always been included as a major topic in courses of school biology. In the more chemical academically oriented programmes emphasis has been given to topics such as the food classes including tests for proteins, carbohydrates and fats; types and sources of food; how plants and animals obtain energy; and digestion, absorption and use of food derivatives by the body. In most courses attention has been given to the use of a balanced diet and to other nutritional aspects of human wellbeing. In some programmes there has been a human focus and in others a comparative approach with a broad treatment across both the plant and animal kingdoms. Many courses also linked this topic to ecology with a treatment of food chains and food webs in the context of community ecology and biogeochemical cycles in nature.

These approaches of course remain valid. These concepts provide the scientific basis for a more socially applied approach. What is now perceived to be essential, however, is to reduce the technical details of this basic science to allow the topic to be dealt with more broadly. In particular links with agriculture need to be established and issues such as primary production of food, processing of food and the storage, supply and distribution of food need to be reviewed. The consumption of food needs to be treated and to be linked to issues such as stocks of food; food and population, safeguarding against famine; cultural determinants in the production and use of food; economic aspects of production and supply and so on. In addition in a course focussing on personal and societal needs modern approaches to food production and storage through research and development should be addressed.

The International Council of Scientific Unions Committee on the Teaching of Science (ICSU-CTS) in planning for its important conference on "Science and Technology Education and Future Human Needs" held in Bangalore India in 1985 (5) issued a useful statement on what a socially oriented programme of school biology should include in the area of food and agriculture (6). Their views are summarised in the following diagram.


STORAGE, SUPPLY AND DISTRIBUTION
- Preservation
- Processing
- Marketing
- Food loss due to spoilage
- Supply and demand (economy)
CONSUMPTION
FOOD
PRODUCTION
- Culture, history, religion
- Over and under consumption
- Health, psychology
- Quality of food
- Intake of additives
- Social factors
- Population factors
- Agricultural factors
- Appropriate technology
- Environmental concerns
- Pollution
- Energy input and output
- Efficiency
RESEARCH AND DEVELOPMENT
- Acceptability of new foods
- Improvement of production
- Appropriate technology
- Biotechnology

Topics in the field of food and agriculture for a school biology programme designed to meet human needs (7)

It is clear that the type of content proposed by ICSU-CTS implies links with subjects such as agriculture, geography, economics and social studies. This is consistent with the world trend towards broadening the aims and objectives of school biology to meet the needs of general education.

ii) Examples of Relevant Content and Activities

Example 6.3 Food needs of the family

School System: Jamaica secondary schools
Approach: Project work on planning family meals
Source: Caribbean Food and Nutrition Institute Food and Nutrition Education A Guide for College Tutors in the English-Speaking Caribbean. Kingston Jamaica: Caribbean Food and Nutrition Institute 1987 p 34

THEME: FOOD FOR THE FAMILY
Unit 2: – Meeting the Food Needs of Different Family Members

OBJECTIVES

To enable students to.

- identify factors in meal planning
- apply factors that influence the food needs of different family members in meal planning.
- plan nutritionally adequate family meals.
- investigate the origins of individual likes and dislikes.
- examine flavour as a factor influencing food likes and dislikes.

TEACHING STRATEGIES

Discussion
Research
Case study
Field trip
Projects

ACTIVITIES

Evaluating daily menus served in the cafeteria and home according to established criteria.

Evaluating menus obtained from magazines, newspapers, eating places.

Interviewing family members and classmates.

Meal Planning.

Reporting on projects.

Keeping daily/weekly food/activity records.

Taste testing different flavours of a particular food and scoring.

Using Recommended Dietary Allowances and Food Composition Tables.

Listing or Sorting foods – foods liked very well and disliked.

CONTENT/ISSUES FOR EMPHASIS

Basics of meal planning – aesthetics nutritional balance, preferences

Rapid assessment of nutritive value of meals – portions and representation of food groups

Conservation of nutrients in food preparation

SOURCES/RESOURCES

Food Groups Charts
Nutrition textbooks
Diet Manual for the Caribbean
Recipe books
Food Budgeting for Caribbean Families 1985.
Food supplements in newspapers
Cases for situation analysis
Resource personnel: Home Economist
Consumer's League or other Consumer group.

Example 6.4: Consumption of food and other resources

School System: Australia secondary school biology
Approach: Inquiry project to investigate the usage of food and other resources by small group
Source: Cohen, David; Hill, Jennifer; McDonnell, Kevin and Meyer, G. Rex Biology Practicals for Senior Students Melbourne: Heinemann Educational Australia 1989 pp 184-185

EB4-2 Inputs and outputs

INQUIRY

To discover the inputs and outputs of a group of humans from an urban ecosystem, and see how these inputs compare with those from a natural ecosystem or a 'developing' country's ecosystem (subsistence).

PROCESS OBJECTIVES

By the end of this activity you should be able to:

1. analyze the inputs and outputs of a group of humans from an urban ecosystem
2. analyze the *source* of these inputs
3. predict the environmental impact of the outputs
4. draw diagrams to compare the urban ecosystem studied with other ecosystems.

MATERIALS

pen and paper

PROCEDURE

A Form a group of about five people. Consider yourselves in the following situation. Your group has rented an apartment on its own. For reasons not clear, you are to spend 4 weeks in this apartment. You have been given a modest amount of money to buy only the things you actually need to keep you together, as a group for 4 weeks in the apartment, in a lifestyle to which you are accustomed.

B Prepare and complete a table in which you will itemize your needs or inputs. Include in your discussion of inputs:

1. their source (including packaging)
2. outputs (from the apartment) for each input
3. the future or impact of the outputs.

QUESTIONS

1. Estimate the percentage of your inputs that required manufacture and/or processing.
2. Estimate the percentage of your outputs which will be:
   - a reused or recycled in a beneficial way
   - b a source of environmental disturbance
   - c neither a or b.
3. Prepare three diagrams:
   - diagram 1 will show the inputs and outputs for an urban ecosystem.
   - diagram 2 will show the inputs and outputs for a natural ecosystem.
   - diagram 3 will show the inputs and outputs for an ecosystem such as that for agricultural or subsistence land use in a 'developing' country.

Example 6.5: Food and population

School System: Malaysia secondary school biology

Approach: Analysis and discussion of maps of world population according to daily food intake of kilocalories and animal protein (Source of maps FAO)

Source: Ministry of Education, Malaysia Modern Biology for Malaysian School Form IV Kuala Lumpur: Longman Malaysia for Malaysian Ministry of Education 1972 pp 54-57

NOTE: RELEVANT FAO MAPS OF WORLD SUPPLIED FOR FOLLOWING READING:

Background reading

World food supply

In figure 50 you will see what at first sight appears to be a misshaped map of the world. The size (area) of each country on the map is a measure of the number of people in that country in 1960. The countries are shaded according to the number of kcal. of energy its inhabitants receive on average each day. It is fairly clear that about one half of the map is given a dark shade, which means that the daily intake of energy is below 2200 kcal. How does this figure of 2200 kcal/day conform with our standard of living in this country? (Q. 5)

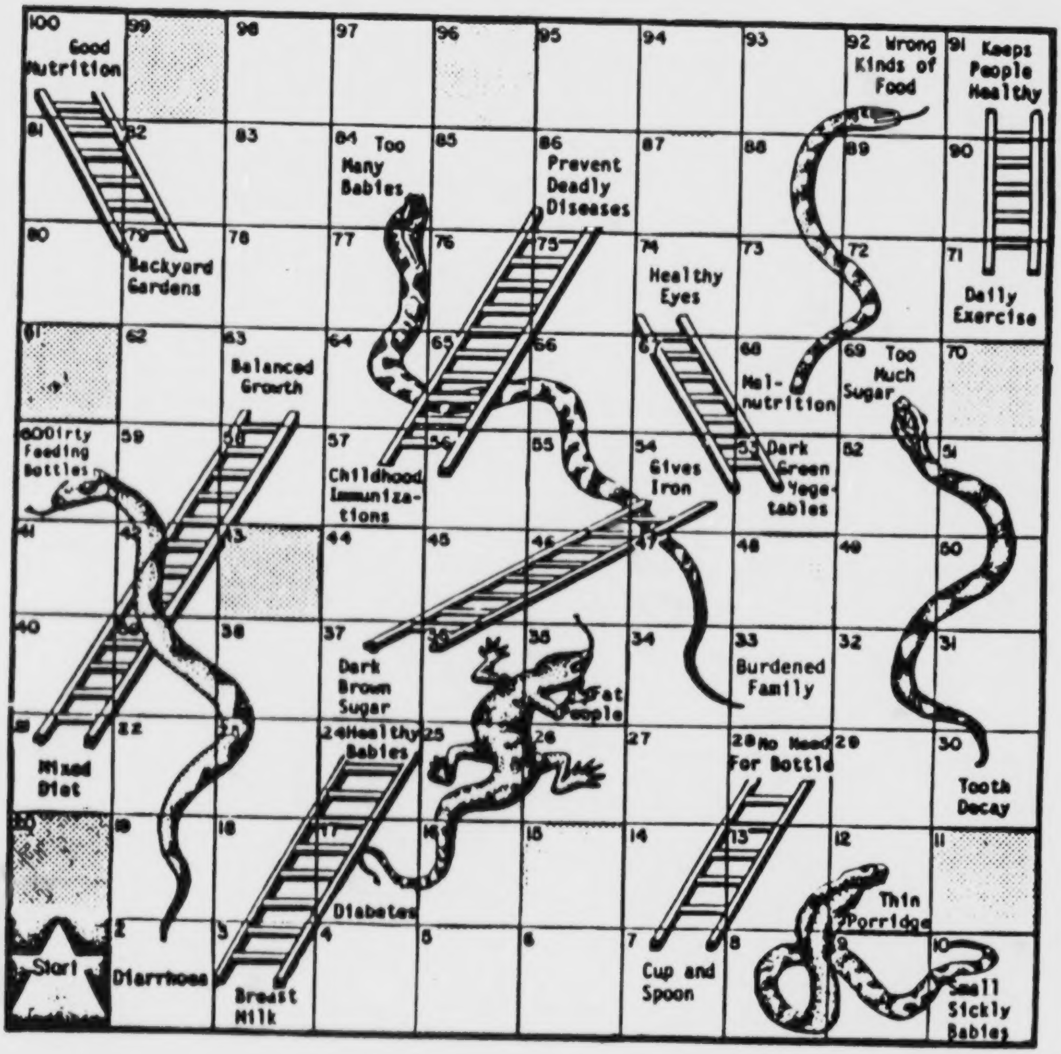
You will see that Malaysia falls into the "2200-2700 kcal/day" group on the first map. What about proteins in our diet? (Q. 6) – see figure 51

You will realise that providing adequate food for the world's growing population is one of mankind's most urgent problems. It is not sufficient to inform people about their food requirements and the values of different kinds of foods. Research workers are able to develop many nutritious foods from unexpected sources. A much greater problem is to encourage people to eat new things. Our eating habits reflect the traditions, culture and religion of our family and most people do not readily accept unusual foods. It is a bigger task in the fight against malnutrition to persuade people to supplement their present diets with foods containing essential nutrition than is the development of suitable foods.

Eating habits are so firmly entrenched that it has sometimes happened that starving people, when supplied with good, but unfamiliar food, have refused or rejected it. An instance occurred when drought followed by floods brought famine in Bengal, Orissa and Kerala in India. The starving people refused wheat or sold it at a very low price using the money to purchase some of the scarce rice at exorbitant prices. As a result, they had far too little to eat. People do change their food habits. In Hong Kong and Malaysia a new drink made from Soya beans has become very popular. Rice has been introduced successfully into West Africa. In India, defatted ground-nut flour is being consumed as fast as it can be made available. In Europe the introduced potato is now an important component of the diet. The novel foods will usually be accepted if sufficient effort is made to suggest simple ways in which they can be cooked and prepared to form a palatable part of the diet.

Example 6.6: Nutritional behaviour

School System: Caribbean secondary school biology
Approach: Simple educational game to create awareness of good nutritional habits.
Source: Caribbean Food and Nutrition Institute Food and Nutrition Education A Guide for College Tutors in the English-Speaking Caribbean. Kingston Jamaica: Caribbean Food and Nutrition Institute 1987 pp 159-160.


100 Good Nutrition
92 Wrong Kinds of Food
91 Keeps People Healthy
84 Too Many Babies
86 Prevent Deadly Diseases
79 Backyard Gardens
74 Healthy Eyes
71 Daily Exercise
63 Balanced Growth
68 Mal-nutrition
69 Too Much Sugar
60 Dirty Feeding Bottles
57 Childhood Immunizations
54 Gives Iron
53 Dark Green Vegetables
37 Dark Brown Sugar
Fat People
33 Burdened Family
Mixed Diet
24 Healthy Babies
28 No Need For Bottle
30 Tooth Decay
Diabetes
Thin Porridge
Start
Diarrhoea
Breast Milk
Cup and Spoon
Small Sickly Babies

Source: CFNI/PAHO

BEST COPY AVAILABLE

Rules

- TWO, THREE OR FOUR PLAYERS MAY PARTICIPATE.
- THE PLAYERS THROW THE DICE, THE PLAYER WHO HAS THE HIGHEST NUMBER STARTS THE GAME BY THROWING THE DICE AND MOVING HIS COUNTER, STARTING AT SPACE 1, ACCORDING TO THE NUMBER SHOWN ON THE DICE.
- IF A PLAYER SCORES A SIX, HE THROWS THE DICE AGAIN. IF A COUNTER STOPS ON THE HEAD OF A SNAKE, THE PLAYER MUST FOLLOW THE COURSE OF THE SNAKE UNTIL HE/SHE GETS TO ITS TAIL, THEN HE CARRIES ON FROM THAT POINT. IF A COUNTER LANDS AT THE FOOT OF A LADDER, THE PLAYER MOVES IT TO THE TOP, AND CARRIES ON FROM THERE.
- BOTH THE SNAKES AND THE LADDERS CARRY MESSAGES THAT THE PLAYER WHOSE COUNTER LANDS ON THE HEAD OF A SNAKE OR THE FOOT OF A LADDER SHOULD READ OUT TO THE OTHER PARTICIPANT/S.
- THE FIRST PLAYER TO REACH 100 IS THE WINNER, BUT HE MUST THROW THE EXACT NUMBER REQUIRED TO WIN. IF THE NUMBER REQUIRED IS TWO, BUT A PLAYER THROWS A FOUR, HE MOVES HIS COUNTER FORWARD TWO SPACES AND BACKWARDS TWO SPACES.

iii) Examples of Project and Test Questions

. Project. Misconceptions about nutrition. Form groups to discuss some of the following topics about which there are misconceptions. Some questions to consider about the information concerning the misconceptions are:

(a) What is the source?
(b) What is the claim?
(c) Does the concept agree with other facts about nutrition that you have learned?
(d) What is the evidence to support the claim?
(e) What do other authorities have to say about the information?

Possible misconceptions are:

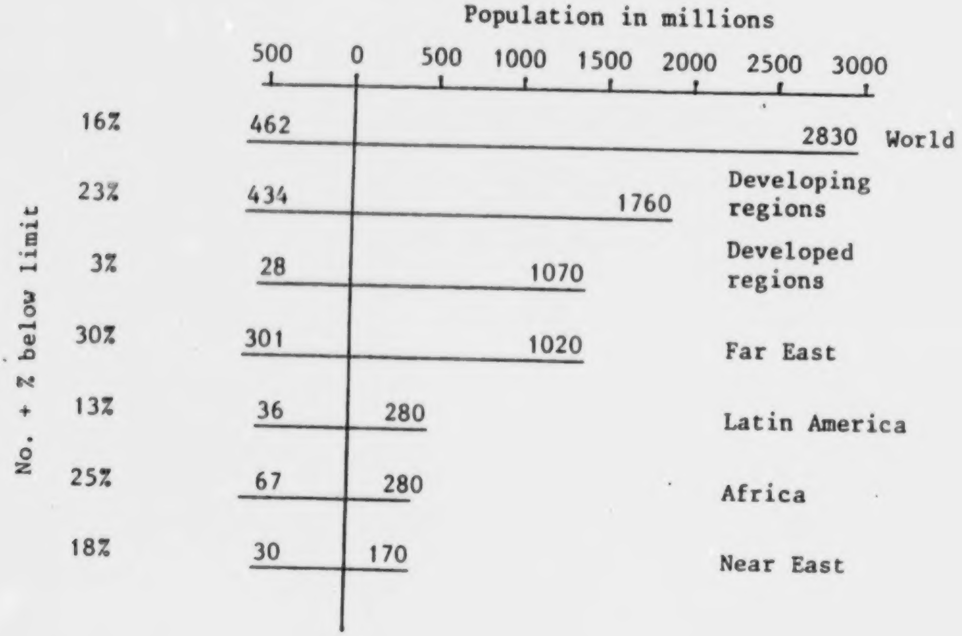
(f) Megadoses of vitamins are effective in treating colds.
(g) Natural vitamins are more effective than synthetic vitamins.
(h) The athlete has a greater need for protein.
(i) Weight control diets are healthy ways to control obesity.
(j) Chocolate and fatty foods are responsible for acne.
(k) Natural foods are nutritionally better than processed foods.

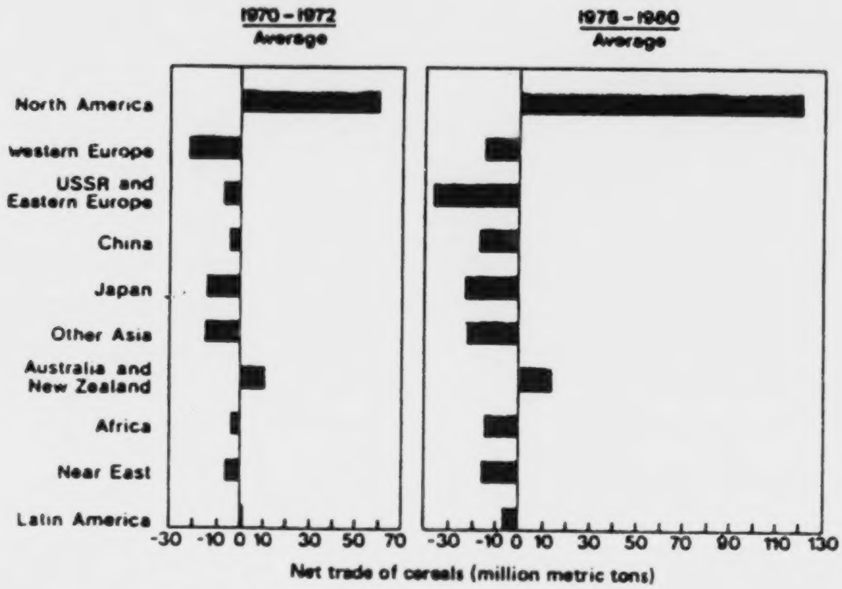
Source: State of Louisiana Department of Education Biology II Curriculum Guide Bulletin 1820 1987 p 68 (slightly modified)

- Project. International distribution of food. Form a discussion group of five. Study the information below and discuss the following issues.
  - (a) Describe and explain any differences you can observe between the developed and the developing world.
  - (b) To what extent might it be said that these differences are due to deliberate economic policies? What other factors could be involved?
  - (c) What might be done to provide all peoples of the world with energy supplies to at least the FAO recommended daily minimum?

Source of diagrams: Rao, A.N. and Pritchard, A.J. Agriculture and Biology Teaching (Science and Technology Education Document Series No 11) Paris: Unesco 1984 pp 27 and 46

The percentage of populations whose energy supply is below FAO recommended daily minimum.





Net trade of cereal grains (million tons):
1970-1972 and 1978-1980.

. Project. Planting Gardens.

(a) The following is a series of questions to help find out about the planing of crops in a garden.

(b) It is most important to find out the reason why things are done in a particular way.

(i) What is the order in which crops are planted in the garden?
e.g. Yams are the first crop planted in many Milne Bay gardens. This is the most important crop and is planted in the most fertile soil.

(ii) What is the method of planting?
e.g. in the New Ireland province, when kaukau is planted, the ground is dug with a digging stick to form a small mound in which the cuttings are planted.

(iii) Are different plants planted in different parts of the garden?
e.g. in the upper Simbu valley sugarcane and bananas are usually grown at the bottom of the garden where the soil is deepest.

(iv) What is the spacing between plants?
e.g. in Milne Bay gardens yams are usually planted about one metre apart.

(v) Do men and women have their own tasks in the planting of the crops?
e.g. in the Eastern Highlands men usually plant bananas, sugarcane, taro, tapioca, bamboo and yams while women usually plant sweet potatoes, maize, peanuts, wingbeans and all leafy vegetables.

(vi) When are particular crops planted?
e.g. Milne Bay gardeners usually plant yams and taro between September and December and sweet potatoes in August and September of the following year. Eastern Highlands usually plant kaukau during August/September and February/March.

(vii) What is the influence of weather on the planting of crops?
e.g. are some plants planted at the end of the dry season? Do gardeners wait for cloudy days to plant some crops?

(viii) Does planting of certain crops take place only at particular phases of the moon?
e.g. some crops planted when the moon is getting bigger (waxing) while others planted when the moon is getting smaller (waning).

(ix) Are there any rituals involved with the planting of some crops etc?
The use of shells and magic words before the planting of yams.

Source: Department of Education Papua New Guinea *Science Traditional Technology Teachers Guide Grade 10 Unit 5* 1981 p 50.

. *Test Questions*

1) In Malawi the common bean (*Phaseolus vulgaris L.*) is an important crop. Both the leaves and the seeds are eaten. The leaves are used as a side dish which provides important vitamins while the seeds provide a side dish rich in proteins. Women pick new leaves of the plant to make the leaf side dish.

Experiments at Bunda College of Agriculture were conducted to determine the effects of this removal of leaves (defoliation) on the yields of seeds. Two types (breeds) of beans were used, the normal (climbing) type and the dwarf type. The results are summarized in the table below.

Treatment	Dwarf Type YIELD kilograms per hectare (kg/ha)	Dwarf Type Percentage reduction in yield by defoliation	Climbing Type YIELD kilograms per hectare (kg/ha)	Climbing Type Percentage reduction in yield by defoliation
No defoliation	1103.4	-	1587.3	-
1 defoliation	1070.3	3.3	1528.9	3.7
2 defoliations	1021.4	7.4	1533.8	3.4
3 defoliations	-	-	1495.7	5.8

1. After which defoliation is the yield greatly reduced in the
   (a) dwarf type? . . . .
   (b) climbing type? . . . . (2)
2. In general, what is the effect of defoliation on bean seed yield?
   . . . . (1)
3. Which type of bean is less affected by successive defoliations?
   . . . . (1)
4. Suggest ONE reason why defoliation causes this effect on yield.
   . . . . (1)
5. In view of the results of the experiments summarized in the figure, what recommendations would you make to people who wish to use both the leaves and seeds of beans? Consider the following points:

   (a) the type of bean to be planted
   (b) the number of defoliations to be allowed.

   . . . .
   . . . .
   . . . . (2)

Origin: Malawi Certificate Examination and Testing Board

Source: Unesco: Unesco Handbook for Biology Teachers in Africa. Paris: Unesco 1986 pp 314-315.

2) Read the following extract from a newspaper article.

INQUIRY INTO BREAD

The Minister for Health, Mr Waddy, said today he would make immediate inquiries into reports that iron and vitamin B were being added to bread in a NSW town as part of a medical experiment.

It was reported in yesterday's "National Times" that the iron and vitamins were being added to all bread made in Bourke, without the townspeople's knowledge.

There have been reports in the United States recently that excess iron can be fatal to some people.

It has been blamed as a cause of cirrhosis of the liver, pancreatic damage, diabetes and heart failure.

(The Sun, Monday 25th February, 1974)

Give one argument for and one argument against the "experiment" as reported in the above article.

3) The table below gives the composition and energy value of a selection of foods.

Food	Composition (g per 100 g)			Kilojoules per 100 g
	Protein	Fat	Carbohydrate	
Sugar	trace	trace	100	1638
Chocolate	9	38	55	2478
Oranges	1	trace	6	113
Cheese	26	31	trace	1638
Wheatmeal biscuits	10	21	66	2016
Sardines	20	23	trace	1218
Peas (dried)	6	trace	17	661

A mountaineer who plans an energetic 3 day trek wants to minimize the weight of his food rations. His food pack for the trip should consist of -

(a) chocolate only, because it provides the most energy per unit mass.
(b) cheese only, because it is a high energy food and also contains the most protein per unit mass.
(c) chocolate, cheese and oranges, since these contain balanced amounts of needed foods.
(d) 200 g of each food listed. . . . . (__)

4) Mark Twain once wrote:

> "Part of the secret of success in life is to eat what you like and let the food fight it out inside."

This statement is unacceptable today. What two features, based on scientific principles, must be taken into consideration in advising an overweight person about suitable diet?

Origin of Questions (2), (3) and (4) Australia: New South Wales Higher School Certificate Biology 1975, 1974 and 1975 respectively.

Source: Meyer, G. Rex "Health Emphasis in Biology Examinations" in Kelly, Peter J. and Lewis, John L. Education and Health (Science and Technology Education and Future Human Needs). Oxford: Pergamon Press for the ICSU Press 1987 pp 259-265.

6.4 The Need for Good Health

i) Rationale

Health studies have been an integral part of the general curricula of both primary and secondary schools for most part of this century. In some school systems a separate subject "Health" has been introduced and in others a cross disciplinary approach has been adopted with all subjects having a role to play. Whatever model is favoured, however, school biology provides an excellent framework for fostering understanding, relevant skills and appropriate attitudes towards health issues.

Unfortunately sometimes this opportunity is missed. For example Professor Saber Selim comments that in Egypt the biology curriculum follows the logical structure of the discipline and its impact on health behaviour is considered of secondary importance. For example the anatomy and physiology of the human body is treated in some detail but very few statements are made about health aspects such as the hygiene of the various systems. Parasitic organisms such as the causative agent of Bilharzia were described as representatives of their animal phylum rather than as a menace to human health and to the economy of Egypt (8).

In a biology programme focussing on human needs health studies, together with other socially relevant topics, should be central to the curriculum and not just be treated as "extras" or "additives" to the conventional structural approach. Further the approach should be positive and should focus on "wellness" rather than the mere avoidance of illness. A classical approach in the past has been to treat a range of human diseases from the point of view of cause and cure rather than prevention and eradication. A positive view should look holistically at the characteristics of a healthy life-style. This is totally consistent with the definition of "health" promulgated by the World Health Organization. This states (9)

> "Health is a state of complete physical, mental and social wellbeing and not merely the absence of disease or informity."

Both physical and psychological aspects of health are the products of an interaction between life style and living conditions (10) and these in turn depend on positive health behaviours by all members of the community. James Ellis and Nancy Landes, writing in Unesco's New Trends in Biology Teaching Volume V, proposed a list of such behaviours and this list is reproduced below (11).

Health behaviours targeted for the curriculum

Area	*Behaviour*
Nutrition	■ Increase consumption of complex carbohydrates in lieu of simple sugar ■ Decrease fat consumption ■ Increase fiber consumption ■ Maintain calorie balance
Fitness	■ Increase exercise for cardiovascular fitness ■ Increase exercise for muscular strength and endurance ■ Increase routine exercises for flexibility
Substance abuse	■ Increase the seeking of help for abusive behaviour for oneself and others ■ Decrease use of marijuana and other illicit drugs ■ Increase proper use of prescription and over-the-counter drugs ■ Decrease cigarette smoking by preventing onset and by increasing cessation ■ Decrease alcohol consumption
Family life	■ Delay onset of sexual activity ■ Reduce incidence of teenage pregnancy ■ Increase positive dating relationships between adolescents ■ Decrease sexual abuse
Injury prevention	■ Decrease risk-taking behaviours ■ Decrease violent behaviour of self and others ■ Decrease suicide ■ Increase reporting of child abuse ■ Increase home safety
Environmental health	■ Decrease exposure to air pollution ■ Decrease exposure to water pollution ■ Decrease exposure to noise pollution ■ Decrease exposure to hazardous substances

Mental health	■ Increase positive peer relationships ■ Increase active involvement in life ('a zest for living') ■ Increase acceptance of individual differences ■ Increase positive communication with family members, authoritative figures and significant others ■ Increase ability to react positively to stressful situations including child abuse and violence ■ Increase positive self-image
Self-care	■ Increase good personal hygiene ■ Increase number of children sleeping appropriate number of hours ■ Increase appropriate self-care for genetically-linked disabilities and diseases ■ Increase correct use of professional help for disease or injury ■ Increase self-treatment for mild illness and willingness to rest and recuperate as needed
Decision-making	■ Identify the problem Describe the problem Exploring alternatives Arrive at a decision Solve the problem

An especially useful list of topics in secondary school biology which can provide frameworks for health studies is given by Professor G. Schaefer in Unesco's Health Education and Biology Teaching (12). Readers are recommended to obtain this publication, especially as the table also includes some helpful suggestions for classroom activities.

Another aspect of health studies within biology is that cultural differences in regard to health behaviours and the concept of "wellness" need to be addressed. The list of behaviours proposed by Ellis and Landes was drawn up for American citizens. Behaviours dealing with, say, use of alcohol and the dating behaviour of teenagers may be inappropriate for other cultures such as, for example, the Arab States. Such differences must be understood and catered for by curriculum developers.

ii) Examples of Relevant Content

Example 6.7: Towards better health

School System: Nigerian secondary schools
Approach: Curriculum guide as objectives, content and activities
Source: Nigerian Ministry of Education Biology for Secondary Schools 1985 p 40

Performance Objectives	Content	Activity
At the end of the lesson, pupils should be able to: 1. describe some ways by which disease-causing micro-organisms and infectious diseases can be controlled. 2. state ways of controlling vectors; 3. list ways of protecting ourselves from . diseases caused by micro-organisms spread by vectors; 4. describe some methods used in disposal of refuse and sewage; 5. state the roles the individual and should play to ensure good living; 6. name some national and international health organisations and provide some descriptions of what they do.	1. Control of harmful micro-organisms. Control of disease-causing micro-organisms: - high temperature - antibiotics - antiseptics - high salinity - dehydration. 2. Vectors: (i) definition (ii) ways of controlling vectors. 3. Pupils' health Maintenance of good health (i) importance to community (ii) ways in which communities do these: (a) refuse disposal (b) sewage disposal (c) protection of water (d) protection of food (e) control of diseases (f) health organisations.	I. Pupils work in groups to perform different aspects of the experiment on control of micro-organisms, using high temperature, antibiotics, etc. Pupils collect results of the separate experinments and discuss. II. Pupils perform experiment to show that spraying a body of stagnant water with a layer of oil can destroy a vector as mosquito. Pupils study the stages in the life cycle of the mosquito, charts, diagrams. Pupils make records of their observation. III. Pupils study charts on the methods of treating refuse and sewage disposal. Listen to talks on public health by local health officials. Write essays on refuse/sewage disposal.

Example 6.8: Cholesterol game

School System: Finland - secondary schools
Approach: A role play activity to increase awareness about health aspects of cholesterol
Source: Game devised by Professor Lyyli Virtanen, Department of Teacher Education, University of Helsinki, Ratakatu 2, SF-00120 Helsinki Finland.

The aim of this game or role play is to air the different views on cholesterol and on what is good for you.

The central person in this role game is Tottie (or Tommy, if male). She is a school psychologist. Her cholesterol count is 8, much too high. She has tried to correct her diet, but nothing seems to help. She functions as a chairperson in this discussion. She is asking for advice, and as usual, good pieces of advice are generously given.

The discussion takes place:

a) in teacher's room, if the game is used in teacher education or
b) in an upper secondary class between a small group of friends, if used in school science teaching.

Other roles:

Hannah (or Harry), she eats only nature products because she believes these are pure and healthy.

Peter (or Peggy), a physical trainer and sprinter.

Ursula (or Ulysses) is a great friend of Italian and French cooking.

John (or Jenny) is a strict headmaster who does not believe in this health nonsense.

Liza (or Luke) is a believer in unrefined, fresh food, in sprouts etc.

Agatha (or Andy), school nurse, believes in rules she has learnt during her education.

James (or Jessica) is a biochemist, his hobby is studying vitamins, trace elements and antioxidants.

The role descriptions:

Divide your class in groups of seven or six. Cut out the roles below and give to the players.

Let the players complete the roles themselves! And if they like, give them time to become acquainted with the role.

Tottie (Tommy) You are really worried. Your doctor told you yesterday that your cholesterol count is still very high, over 8. And you have not eaten anything that contains cholesterol. When you buy anything to eat, you thoroughly read the descriptions and try to avoid anything that contains cholesterol. You are not obese, you are in good shape, if not a real fitness fan. You obey your doctor's advice. You like good common food. You are the moderator in this discussion.

Hannah (or Harry) You are a health shop customer and eat only nature products because you believe these are pure and healthy and light. You do not believe in ordinary doctors, you prefer keeping yourself fit. Your freezer is full of nettle leaves and you grow herbs and horse tails in your garden to make teas.

Peter (or Peggy) You are a physical trainer and sprinter. You are just now reaching the top. You believe in a man's free will and ability to control his own life. Mens sana in corpore sano! Your coach has planned for you a special diet but of course you like heavy parties too. A winner needs to relax!

Ursula (or Ulysses) You are a great friend of Italian and French cooking. You use freely butter, olive oil and cream in your cooking. Of course vegetables and herbs too. Your figure is getting a bit round, but you are fun and cheerful. You love to spoil your family and friends with good meals with excellent wines.

John (or Jenny) You are a strict school headmaster who does not believe in this health nonsense. Old fashioned country food is still good, bread and butter, porridges, beef with gravy, kippers. A beer and a scotch on the rocks are your favourite vegetables. Maybe smoking is not so healthy, you try to avoid it, but a good cigar belongs to a nice dinner! Your father is now over 80, still very fit and has never eaten those lettuces.

Liza (or Luke) You are a believer in unrefined, fresh food, in sprouts etc. You grow your own food, sprouts and lettuces on your window sills. You are a strict vegetarian. Your migraines and stomach aches disappeared totally after you changed your diet. No cooked meals, cooking and frying and animal foods are the beginning of bad health. You can make delicious servings of living food.

Agatha (or Andy) You are the school nurse. You believe in knowledge and rules you have learnt during your education. You feel it is your plight to give further all that good information the national health board is sending you. So you are always lecturing on good health habits to all your friends and students. Sure, the National Board is right, following its advice is the best guarantee to good health!

James (or Jessica) You are a biochemist, your hobby is studying vitamins, trace elements and antioxidants. You have a theory of your own; certain trace elements and good health are interacting. You know all the fatty acids and their bonds between the carbon atoms. Your love to cook meals with plenty of all those; vitamins, minerals (not natrium) and antioxidants.

Note: Following the actual role play undertake the usual debriefing and discussion. Try to work out a set of guidelines for the wellbeing of Tottie (Tommy).

Example 6.9: Visit to local hospital

School System: Australia. Secondary schools New South Wales school years 11-12
Approach: Guidelines for interviewing hospital staff and for preparing a report
Source: Cohen, David; Hill, Jennifer; McDonnell, Kevin, and Meyer, G. Rex Biology Practicals for Senior Students. Melbourne: Heinemann Educational Australia 1989 pp 172-173

EB2-4 *Visit to local hospital*

It is recommended that this visit is arranged by the teacher in charge of the class, and that it be undertaken by one group of two or three students. These students should report their findings to the whole class. A tactful approach by the teacher to the Medical Superintendent of the hospital will, in most cases, be rewarded by permission for such a visit. It is stressed, however, that medical staff are extremely busy and it may not always be possible for permission to be granted. In such cases the local Health Inspector at the Council Chambers may be willing to give an interview. In this case the questionnaire below should be modified to suit.

INQUIRY

To discover what information can be provided about infectious diseases by the local hospital.

PROCESS OBJECTIVES

By the end of this activity you should be able to:

1 carry out an interview in order to gain information about infectious diseases
2 present the results of the interview as a written report.

MATERIALS

questionnaire (based on questions given below)
clip board
pencil or ball point pen

PROCEDURE

A Interview the medical superintendent and staff asking the following questions.

1 *Incidence of infectious diseases*

- What is the size of the hospital?
- How many patients suffering from infectious diseases are admitted in a year?
- Which infectious diseases are regarded as the most serious?
- Which infectious diseases are notifiable?
- What types of infectious disease have been treated at the hospital within the last year?
- Are there any infectious diseases in which the incidence is increasing or decreasing? If so which ones?

2 *Causative factors*

- What are some of the types of disease-causing organisms?
- Are there any particular factors in our district which cause diseases to be spread? (Lack of adequate sewerage facilities, swimming pools, garbage disposal facilities.)
- How are the common infectious diseases transmitted?
- Are there any seasons in which certain infectious diseases are more prevalent?

3 *Detection of infectious diseases*

- What symptoms indicative of infectious diseases should be investigated by a doctor?
- What part is played by pathologists in the detection of infectious diseases?
- What methods do pathologists use in identifying pathogens?
- Does the hospital have any special instruments for the detection of infectious diseases?

4 *Prevention and control*

- What methods are used in the community to prevent the spread of disease?
- What special methods are used in the hospital to prevent the spread of infectious disease?
- Does the hospital have an isolation ward?
- Does the hospital have a quarantine section?
- What precautions are taken to treat the room and the materials used by a patient who has been suffering from an infectious disease?
- What special precautions are taken to prevent infectious diseases reaching babies in the hospital?
- What precautions are taken to ensure that the medical staff at the hospital do not contract infectious diseases?

B Write up the interview in the form of a report for presentation to the class for discussion.

Example 6.10: Use of traditional medicine

School System: Philippines secondary schools
Approach: An account of a simple traditional procedure for curing roundworm infection
Source: Philippines Ministry of Education "The Roundworms" Science and Technology II (Trial Edition). Manila: Ministry of Education and Sports 1986 pp 410-413. Made available courtesy of University of Philippines Institute for Science and Mathematics Education Development (UP-ISMED)

Cure of worm infection. The seed of a plant, locally known as niyog-niyugan, can be used as a purgative or de-wormer. Herbolarios or quack doctors have been giving niyog-niyugan seeds to their patients. Doctors and medical researchers have attested to the effectivity and safety of niyog-niyugan as a de-wormer. Usually, three seeds are taken for three days. Niyog-niyugan is effective against roundworms like Ascaris and hookworms. (See UP-ISMED module Kalaban ng Bulati si Niyog-niyugan).

Squash seeds can also be used as a de-wormer. This is effective for tapeworms. The squash seed preparation is made by mixing 15-25 tablespoonfuls of pounded squash seeds with milk or sugar solution enough to fill a cup. This preparation is taken early in the morning and is followed by taking a purgative two hours later. (See UP-ISMED module Medicinal Vegetables and Spices).

Many locally available plants and plant preparations are being used not only as de-wormers but also for the cure of many kinds of diseases. Many plants, like squash and niyog-niyugan, can be planted right in your backyard or vacant lot in the community. Those that are not available in your community can be obtained from places like the "botika sa baryo" and in market places. These plants and plant preparations cost less than the usual medicines bought in drug stores.

Activity 1. - Make a list of as many different plants and plant preparations used for medicine in the Philippines. Know how and where the plants are grown and how plant preparations are made. Give the dosage needed to cure a particular disease or infection.

Remember, self-medication can sometimes do you more harm than good. Because of this, always consult a doctor or other qualified health worker if you are sick. Take niyog-niyugan or any other plant or plant preparations only when prescribed by your doctor.

Something to Discuss

Whom will you consult when you get sick, a doctor, an herbolario (quack doctor), or both? Why? Whom do you think is really more qualified to render medical services? Why? Would you prefer to take herbal medicines or the usual drug store medicines? Which do you think is safer? Get the opinions of other people in your school or in your neighbourhood regarding these matters.

Examples of Project and Test Questions

- Project: What Provides Immunity.

Source: USA. Biological Sciences Curriculum Study Immunology and Human Health. Colorado Springs: BSCS 1986 pp 58-59

ACTIVITY WHAT PROVIDES IMMUNITY?

In this activity you will investigate some theories about the human immune system. The activity includes readings and points for discussion and asks you to make observations from data.

Introduction

For many years, scientists did not understand why only those people who had recovered from the plague could safely care for the ill

The germ theory of disease, developed in the late 1800s, proposed that microorganisms cause disease. The idea that a specific organism could cause a specific disease enabled scientists to propose hypotheses about prevention and treatment. One hypothesis, for example, was that killing or weakening the organism would enable an infected person to recover. Research also led to questions about how the body resists or overcomes infection. Consider the following experiment:

Diphtheria is a bacterial disease that attacks the upper respiratory system, the nose, throat, and tonsils. The disease is caused by the bacterium *Corynebacterium diphtheriae.* The bacteria produce a *toxin* that destroys nerve cells and eventually causes heart failure. A toxin is a poison produced by a disease-causing organism. The toxin produced by *C. diphtheriae* is more deadly than cobra venom. Diphtheria can be fatal if not treated promptly. It is especially serious in young children.

Scientists heated this toxin to cause the destruction of its poisonous properties. The resulting substance is called diphtheria *toxoid.* Toxoid was injected into two rabbits. Two weeks later, blood samples were collected from the rabbits, the cells were removed, and the plasma—the liquid portion of the blood—was saved. The following experiment was then carried out with three groups of mice.

Group 1. Twenty-five mice were injected with diphtheria toxin.

Group 2. Twenty-five mice were injected with plasma from a healthy rabbit. Ten minutes later they were injected with diphtheria toxin.

Group 3. Twenty-five mice were injected with the plasma saved from the two rabbits that had been injected with diphtheria toxoid. Ten minutes later those mice were injected with diphtheria toxin.

Figure C-1 shows what the scientists observed on the following day. Consider the questions in on the worksheet. Record your answers on the worksheet.

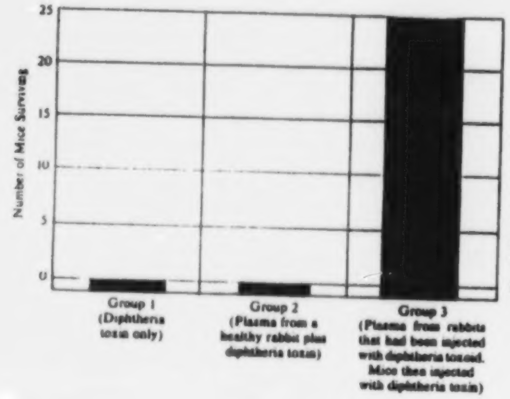


Figure C-1. The survival of three separate groups of mice. Group one was injected with diphtheria toxin. Group two was injected with plasma from a healthy rabbit and then with diphtheria toxin. Group three was injected first with plasma from rabbits injected with diphtheria toxoid. The mice in group three were then injected with diphtheria toxin. (BSCS, 1986.)

Worksheet:

1. Provide two possible explanations for the fact that the injected rabbits did not die from diphtheria.

2. What are possible explanations for the deaths of the mice in group 1?

3. What are possible explanations for the deaths of the mice in group 2?

4. What do the deaths of the mice in group 2 suggest about normal rabbit plasma?

5. How can you explain the lack of illness in the mice in group 3?

6. The experimenter used plasma taken from the rabbit that was injected with the diphtheria toxoid, and plasma from the normal rabbit. What is different about the two plasmas, based on the data?

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7. Does plasma contain cells?

8. What could be in plasma that could transfer immunity to a disease from one animal to another?

. Project: Sexually Transmitted Disease

Source: Papua New Guinea Ministry of Education: Science Growth and Reproduction Teachers Guide Grade 8 Unit 5 Revised Investigation 8 Sexually Transmitted Diseases 1985 p 6

(Note: Text provided for completing the following worksheet)

STUDENT WORKSHEET - SEXUALLY TRANSMITTED DISEASES

1. Fill in the spaces in the table below:

DISEASE	HOW IT SPREADS	SIGNS	HOW IT IS TREATED
GONORRHOEA			
SYPHILIS		1st stage 2nd stage 3rd stage	
DONOVANOSIS			
AIDS			

2. The number of people in many parts of the world, including Papua New Guinea, suffering from S.T.D. is increasing every year. Suggest some ways in which you think the spread of S.T.D. could be prevented.

- Project: Aspects of Disease and Immunity

Source: USA: Biological Sciences Curriculum Study (BSCS) Immunology and Human Health Colorado Springs: BSCS 1986 p 31

Note: The following project questions follow a series of readings and activities.

- Why do some people get sick while others do not?
- Why do we get immunized against some diseases and not others?
- Do other organisms have immune systems?
- Can you be born with a disease?
- Why do some people get sicker than others with the same disease?
- Why do antibiotics work against some diseases and not others?
- Why do some immunizations confer life-long immunity, while others require "boosters"?

- Test Questions

1. Figure 6 shows the relationship between the annual death rate from lung cancer among men and the number of cigarettes smoked per day.

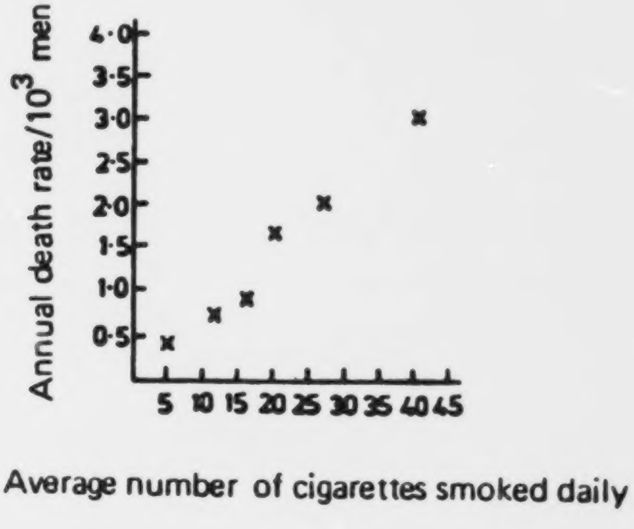


Figure 6. Annual death rate from lung cancer among cigarette smokers

(a) (i) On average how many men who smoke 40 cigarettes a day die from lung cancer in a year?

(ii) What is the ratio of the annual death rate among men who smoke 40 cigarettes a day to the annual death rate among those who smoke 5 cigarettes a day?

(b) It is claimed that cigarette smoking affects the smoker's digestion by reducing the flow of gastric juice.

(i) Suggest how it is possible for cigarette smoking to cause a reduction in the flow of gastric juice.

(ii) Explain how a decrease in the flow of gastric juice could affect digestion.

(c) It is also claimed that cigarette smoke is as harmful to non-smokers inhaling it as to the smokers themselves.

Consider the claims in (b) and (c) and the data given in Figure 6. Should there be a ban on cigarette smoking in your country? Give reasons for the position you take.

(KNOWLEDGE 2 marks, ENQUIRY SKILLS 6 marks, ATTITUDES 2 marks)

2. Graph A shows the amount of antibody formed in the bloodstream after the first injection of a certain antigen and graph B shows the amount of antibody formed in the bloodstream after a second injection of the same antigen.

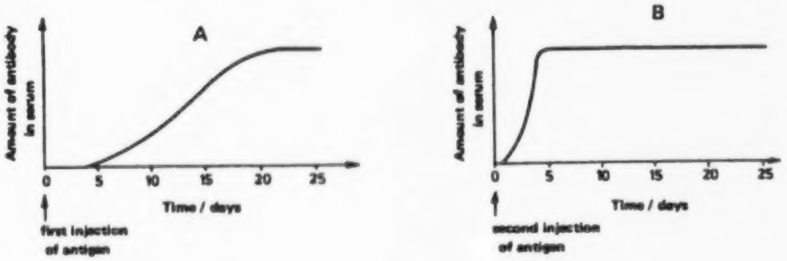


Figure 1 The production of antibodies after injections of antigen.

(a) How long did it take for antibodies to appear in the bloodstream after the first injection?

(b) How long did it take for the maximum amount of antibodies to be formed in each case? Suggest a reasdon for the difference in time.

(c) In a household two out of five teenagers were unaffected by a bacterial disease known as diphtheria when it broke out in the neighbourhood. Which of the two graphs, A or B, would most closely represent the body's response to the disease in the case of the two unaffected children? Give a reason for your answer.

(d) You are a Health Officer and there is an outbreak of diphtheria in your community. Some parents refuse to allow their children to be immunised against the disease. (Diphtheria attacks the glands in the throat and can cause death.) What would you do?

(KNOWLEDGE 3 marks, ENQUIRY SKILLS 5 marks, SOCIAL AWARENESS 2 marks)

Source of Test Questions 1 and 2: Caribbean Examination Council (CXS) Past Papers General Proficiency. Kingston: CXS 1983 pp 40 and 52.

3. (a) Explain why the proportion of old people in our society has increased and will continue to do so.

(b) What special help do old people need, and should they receive it from public organizations or from their relations and other private helpers?

(c) What will be the effects of increased expectation of life combined with the likelihood of a lowering of the normal age of retirement?

Source: UK Science Society Examination June 1983. Cited in Kelly, Peter J. and Lewis, John L. Education and Health (Science and Technology Education and Future Human Needs Volume 5). Oxford: Pergamon Press for the ICSU Press 1987 p 268

4. During the Great Plague of London, people did a variety of things to protect themselves from the plague. Some were effective, some were not. Evaluate these behaviours according to the following key.

KEY: A. Would likely decrease the chance of getting plague.
B. Would likely increase the chance of getting plague.
C. Would likely not be effective one way or the other.

1. (C) Many people refused to drink water from the wells of London.

2. (B) Some people gathered together in large groups protesting that the authorities were not doing enough to protect them.

3. (A) Many people left London and moved to very isolated areas.

4. (B) Thousands from rural areas went to London.

5. (B) Some locked themselves in cellars away from the light.

6. (C) Many consulted with witch doctors, astrologers, and fortune tellers.

To protect a human population from the plague, all but one of the following would be effective. Which one would not be:

A. Isolate people from one another as much as possible.

B. Reduce the rat population as much as possible.

*C. Boil all drinking water.

D. Maintain the health of the population through good nutrition habits.

Source: Biological Sciences Curriculum Study (BSCS) Immunology and Human Health Colorado Springs: BSCS 1986 p 31

5. In the USA there are HMOs (Health Maintenance Organizations). You pay them a lump sum, and in return they maintain your health for the following year by meeting your medical needs, including any necessary hospital treatment.

If you were setting up an HMO and planning a scale of charges reflecting the probable costs, what enquiries would you make into the life style of applicants? Indicate the broad principles on which you would assess risk without trying to quantify them.

Source: UK Science-in-Society Examination June 1985. Cited in Kelly, Peter J. and Lewis, John L. Education and Health (Science and Technology Education and Future Human Needs Volume 5) Oxford: Pergamon Press for the ICSU Press 1987 p 269

6.5 Need for Effective Hygiene and Sanitation

i) Rationale

Clearly these topics are part of the broader issue of health but because of their central importance in ensuring the wellbeing of all citizens and because there are special problems in some developing countries, they are treated separately. Aspects of hygiene and sanitation also relate to aspects of shelter and to food and nutrition and some examples related to these needs are included in this section.

The need for effective hygiene and sanitation can be readily reviewed within the biology curriculum. For example personal hygiene can be studied from the point of view of parts of the human body - skin, hair, eyes, nose, ears, teeth, feet, external sex organs, and internal organs. Physiological topics such as the digestion and absorption of food, movement, excretion and reproduction can be given a strong hygiene emphasis and the availability of resources such as clean food and water, unpolluted air and hygienic clothing, housing materials and furnishings can be discussed in both physiological and biological areas of the syllabus.

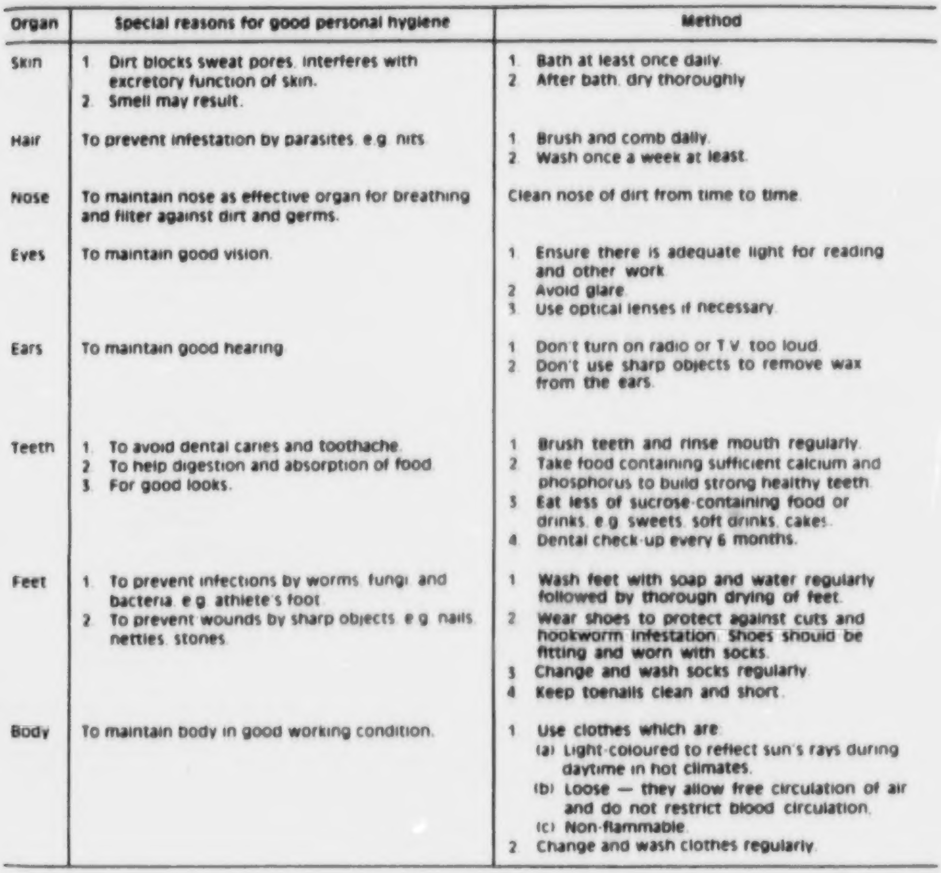
In considering the issue of shelter, in particular human housing, hygiene and sanitation aspects of village, town and city planning can be reviewed and the need for planned community policies and programmes for the maintenance of good hygiene and sanitation can be emphasised.

This challenge has been accepted by many school systems, especially in the Third World. Topics given special emphasis include maintenance of personal hygiene, hygienic handling of food, provision of clean water, hygienic disposal of sewage and garbage and general community hygiene.

ii) Examples of Relevant Content

Example 6.11: Hygiene of the external human body

School System: Singapore secondary school human biology
Approach: Summary table by organ, reasons for hygiene and methods of good hygiene
Source: Secondary school course in Human and Social Biology Phoon, W.O., Chew, P.K., Goh, E.H. Comprehensive Human and Social Biology Third Edition. Singapore: Federal Publications 1986 p 257



Organ	Special reasons for good personal hygiene	Method
Skin	1. Dirt blocks sweat pores, interferes with excretory function of skin. 2. Smell may result.	1. Bath at least once daily. 2. After bath, dry thoroughly.
Hair	To prevent infestation by parasites, e.g. nits.	1. Brush and comb daily. 2. Wash once a week at least.
Nose	To maintain nose as effective organ for breathing and filter against dirt and germs.	Clean nose of dirt from time to time.
Eyes	To maintain good vision.	1. Ensure there is adequate light for reading and other work. 2. Avoid glare. 3. Use optical lenses if necessary.
Ears	To maintain good hearing.	1. Don't turn on radio or T.V. too loud. 2. Don't use sharp objects to remove wax from the ears.
Teeth	1. To avoid dental caries and toothache. 2. To help digestion and absorption of food. 3. For good looks.	1. Brush teeth and rinse mouth regularly. 2. Take food containing sufficient calcium and phosphorus to build strong healthy teeth. 3. Eat less of sucrose-containing food or drinks, e.g. sweets, soft drinks, cakes. 4. Dental check-up every 6 months.
Feet	1. To prevent infections by worms, fungi and bacteria, e.g. athlete's foot. 2. To prevent wounds by sharp objects, e.g. nails, nettles, stones.	1. Wash feet with soap and water regularly followed by thorough drying of feet. 2. Wear shoes to protect against cuts and hookworm infestation. Shoes should be fitting and worn with socks. 3. Change and wash socks regularly. 4. Keep toenails clean and short.
Body	To maintain body in good working condition.	1. Use clothes which are: (a) Light-coloured to reflect sun's rays during daytime in hot climates. (b) Loose — they allow free circulation of air and do not restrict blood circulation. (c) Non-flammable. 2. Change and wash clothes regularly.

Example 6.12: Personal hygiene habits

School System: Republic of South Africa secondary schools
Approach: Simple illustrated rules set out in point form
Source: Abrahams, J.C. and Du Toit, J.H. Health Education Standard 3. Cape Town: Juta and Co Ltd, 1978 pp 20-21

PUBLIC HEALTH

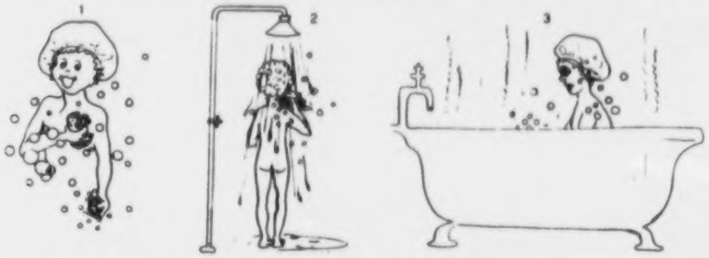
What we already know

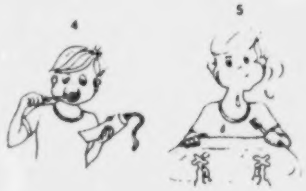
1. People who are dirty smell unpleasant.
2. Cavities (holes) form easily in teeth if you do not brush your teeth regularly.
3. People who have cavities in their teeth usually have a breath that smells unpleasant.
4. If a person is ill, he can easily infect others.
5. Germs cause infectious diseases.
6. Germs are everywhere.
7. The body can defend itself against most germs.
8. Flies spread germs because they are filthy.

PERSONAL HYGIENE

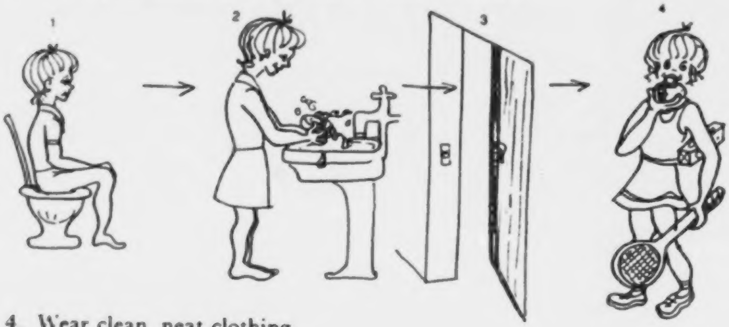
If everyone is clean and healthy, germs will not have the opportunity to make people ill. You can also contribute your share in the fight against diseases.

1. Wash, take a shower or bath regularly everyday with warm water and soap. Warm water and soap help to remove germs.

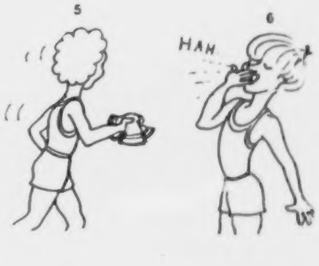




2. Brush your teeth regularly every morning and evening. Rinse your mouth after meals. Germs live in food particles which are lodged between your teeth.
3. Wash your hands after you have visited a toilet.



4. Wear clean, neat clothing.
5. Keep your hair clean and tidy.
6. Hold your hand or handkerchief in front of your mouth and nose while you cough or sneeze.
7. Never spit. It is extremely ill-mannered and unhygienic.



GENERAL

Germs cause people to become ill. The authorities want people to remain healthy. They therefore try to fight germs.

Municipal authorities see to it that germs are destroyed in different ways. Let us look at a few examples.

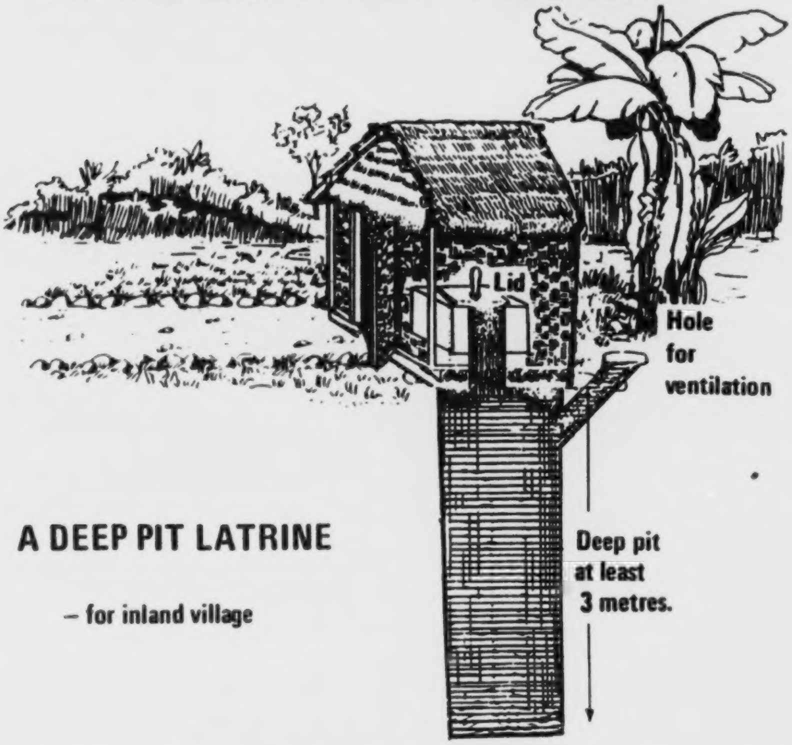
Public Health Services:

1. Purification of water.
2. Removal of sewage.
3. Removal of garbage.
4. Immunization.
5. Prevention of air pollution.
6. Control over the delivery and supply of pure milk.

Example 6.13: Construction and use of hygienic latrines and toilets

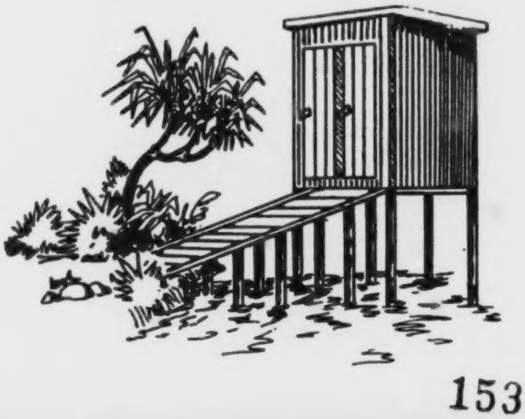
School System: Papua New Guinea secondary school science
Approach: Simple diagrams for use as posters or as masters for OverHead Transparencies (OHTs)
Source: Department of Education Papua New Guinea Science Microbiology Teachers Guide Grade 10 Unit 3. Boroko: Department of Education 1988 pp 137-140

LATRINES OR TOILETS



A DEEP PIT LATRINE

– for inland village

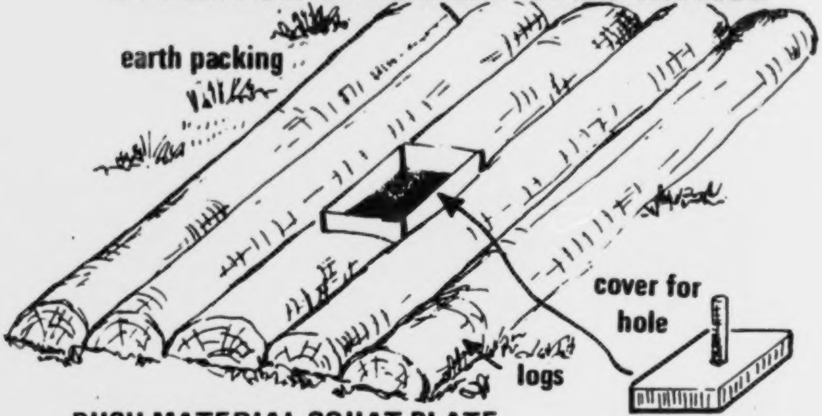


A SEA LATRINE

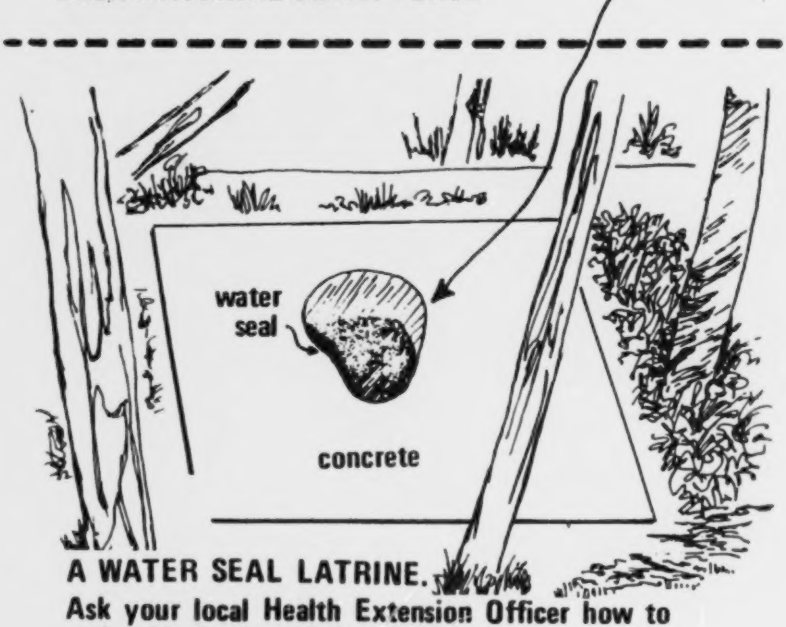
– for village on the coast.

This should be built over a site where there is always sea water

SIMPLE LATRINES VILLAGE PEOPLE CAN MAKE


earth packing
cover for hole
logs

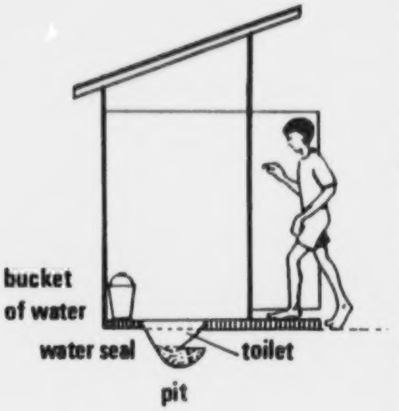
BUSH MATERIAL SQUAT PLATE


water seal
concrete

A WATER SEAL LATRINE.

Ask your local Health Extension Officer how to make this simple and clean latrine.

WATER SEAL TOILET


bucket
of water
water seal
toilet
pit

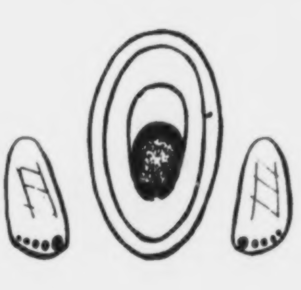
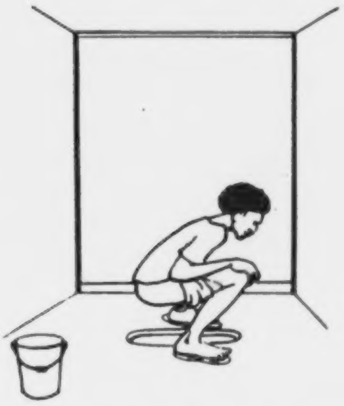
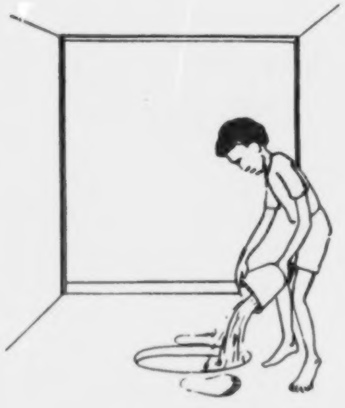
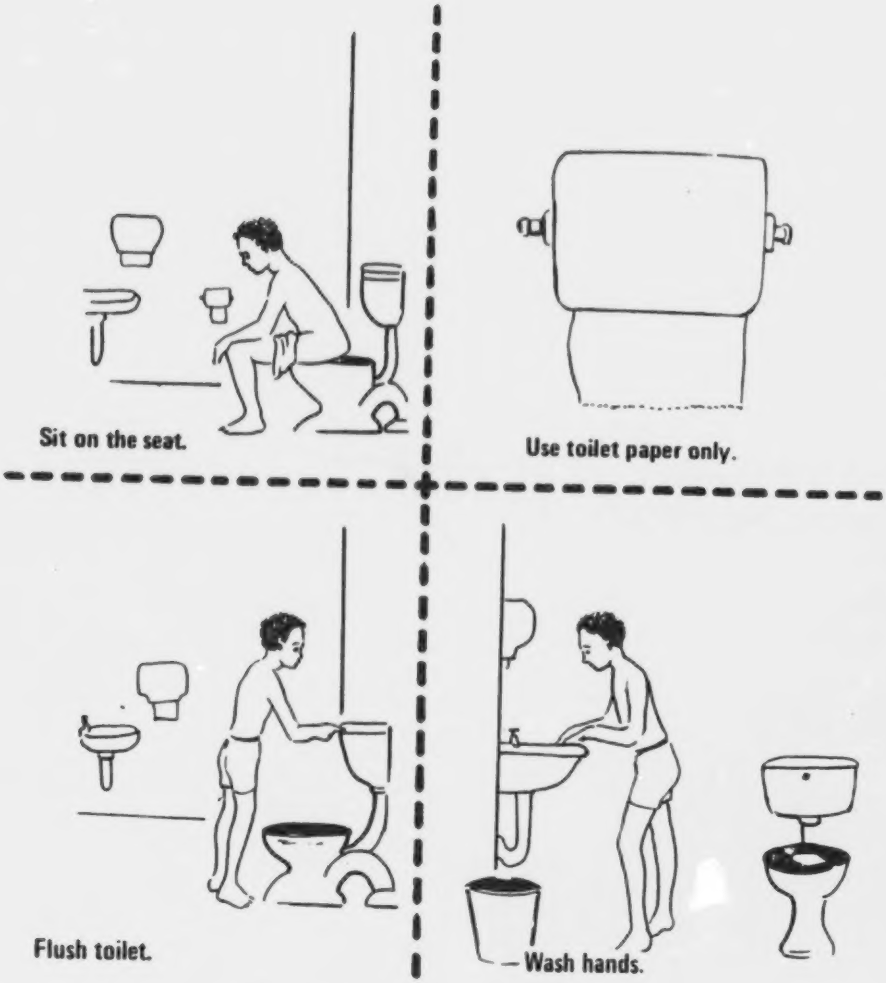


Diagram of squat plate


How to use squat plate


To clean after use pour water from front

HOW TO USE A TOILET


Sit on the seat.
Use toilet paper only.
Flush toilet.
Wash hands.

KEEP THE TOILET CLEAN

Example 6.14: Study of garbage

School System: Australia - New South Wales secondary biology
Approach: Practical activities and discussion designed to heighten awareness about the need to recycle garbage
Source: Cohen, David; Hill, Jennifer; McDonnell, Kevin, and Meyer, G. Rex Biology Practicals for Senior Students. Melbourne: Heinemann Educational Australia 1989 p 191

EB5-3 Study of garbage

With the increase in problems associated with disposal of domestic waste, state and local governments have launched programs encouraging householders to handle garbage in ways other than the conventional 'dumping'.

This activity will help you to gain insights into some alternative methods of disposal which may be employed.

INQUIRY

To investigate types of waste and how waste can be recycled.

PROCESS OBJECTIVES

By the end of this activity you should be able to:

1 make a detailed study of a sample of human garbage
2 reach conclusions about the environmental impact of the items studied.

MATERIALS

a parcel of houshold refuse brought from your home (e.g., the waste package from your previous evening's meal—including preparation)

large beakers

2 M sodium hydroxide solution (avoid contact with skin)

PROCEDURE 1

A Open the package of refuse and make a list of *every* distinct material it contains, e.g. animal bone, fruit peels, glass, cardboard, etc.

B For each of the items in your list, answer *yes* or *no* with respect to the accuracy of each of the following statements.

  1 Composed largely of carbon compounds.
  2 Formed from the body of a living thing.
  3 Able to be reused immediately.
  4 Able to be reused after a purely *physical* process (e.g., melting down).
  5 Able to be reused after undergoing *chemical* changes in a factory or industrial plant.
  6 Able to be reused after undergoing chemical changes which occur spontaneously in nature (decomposition by decay).
  7 Not reusable at all.
  8 Combustible.
  9 A suitable raw material for making some product not initially in the garbage.

Draw up a table to summarize your decisions for each item of refuse.

PROCEDURE 2

To help you come to conclusions regarding each of the items, you ought to carry out the following simple investigations.

A Study the effect of 2 M sodium hydroxide solution on paper and paper products.

B Place soft plant tissue (e.g. fruit peelings) in a beaker. Keep moist and observe over a period of weeks.

C Germinate two sets of seeds in washed sand. Give one set distilled water only, but sprinkle the other with crushed animal bone. (Dry for 24 hours in an oven at 150°C before crushing.) Compare the vigour of each set of plants.

D Use library resources and the public relations officers of local factories to find out the meaning of the terms 'cullet', 'biodegradable', 'recycling', 'detinning'.

QUESTIONS

1 Does refuse contain more organic than inorganic wastes?

2 Is most refuse biodegradable?

3 What steps could a householder take to reduce the amount of material he or she places in the rubbish bin? Which of these steps is 'ecologically sound'?

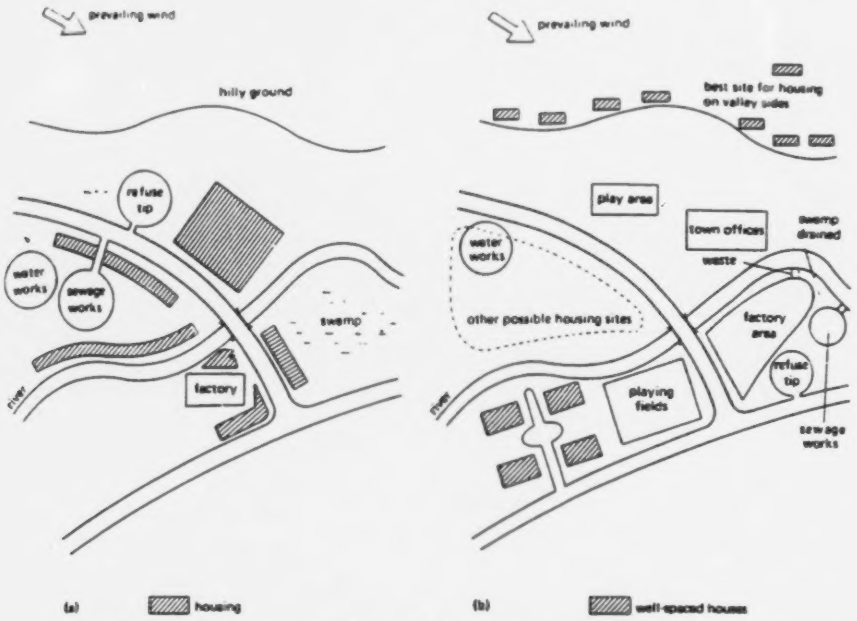
FURTHER INQUIRY

1 Charities and hospitals often conduct 'paper and rag drives'. Find out why they collect these materials and how they are ultimately used.

2 Study goods displayed in a local store and decide whether the term 'overpackaging' could be used to describe any of them.

Example 6.15: Hygienic town planning

School System: Caribbean secondary schools
Approach: Comparative town plans as stimulus for class discussion
Source: Soper, R.; Tyrell Smith, S., and King, W.K. Caribbean Biology for CXC An Integrated Approach. Third Edition. London: Macmillan 1985 p 237


prevailing wind
hilly ground
refuse tip
water works
sewage works
swamp
factory
river
prevailing wind
best site for housing on valley sides
play area
town offices
swamp drained
water works
waste
other possible housing sites
factory area
refuse tip
playing fields
sewage works
river
(a)
▨ housing
(b)
▨ well-spaced houses

(a) Plan of a town with poor siting of buildings and services (b) Plan of the same site based on hygienic principles

iii) Examples of Project and Test Questions

. Project. Sources of Water and their Protection.

Source: Lindskog, Per "Some Teaching Examples on Water Resources" in Graves, Norman J. Land, Water and Mineral Resources in Science Education (Science and Technology Education and Future Human Needs Volume 4) Oxford: Pergamon Press for the ICSU Press 1987 pp 154-155.

Your water source and its protection

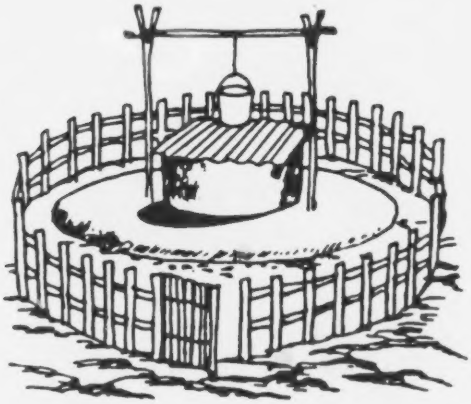
Question: What water sources are used by the families from which the students come?

Find out the sources of water supply in the community. Do this as a class activity. Your teacher will help you make the necessary arrangements. Select one class from every year level of your school. Ask the students to check their sources of water. You may have to explain the meaning of each water source. Count the number of students in each class who chose a given source of water. Do the same with all the other sources. Summarize your findings in your notebook, in a table like Table 8.4.

TABLE 8.4. *The Sources of Water used by Families in the Community.*

Source	Number of students by Year level				
	First	Second	Third	Fourth	Total
Rain					
Well					
Spring					
River					
Lake					
Public tap					
Private tap					

The safety of these different water sources varies a lot. Taps are usually safest, followed by springs and rain water. If your water source is an unprotected well, it is very easy to give source protection by covering the well and keeping animals away with a fence, Fig. 8.1.



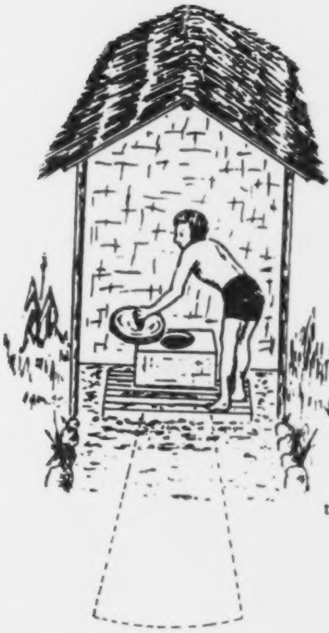
Keep animals away from the well. If this is a problem build a fence with a door that is easily opened and closed.

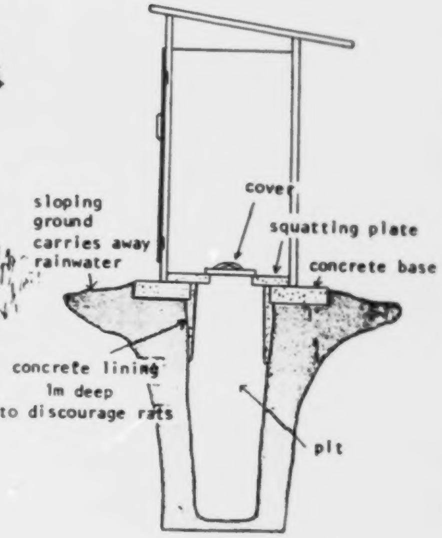
FIG. 8.1

- Project. Building a deep pit toilet.

Source of pictures and descriptive paragraph: Department of Education Papua New Guinea Science Microbiology Teachers Grade 10 Unit 3. Boroko: Ministry of Education 1985 p 135

DEEP PIT TOILET




sloping ground carries away rainwater
cover
squatting plate
concrete base
concrete lining 1m deep to discourage rats
pit

This sort of toilet has a very deep hole. The hole should be about 6m deep and about 1m across. This hole is covered by a floor or a seat with a hole in it, and a lid covers this hole so that flies cannot get in.

Advantages

- When people have done the work of digging the hole there is no more work to do. It does not have to be emptied like a bucket.
- Because it is deep, flies do not like going inside it and it is easy to build a floor that will keep them out.
- Faeces and urine soak away in the earth and so the hole does not fill up for a long time.

Discuss some of the problems in building a deep pit toilet. Put down some things that must be done to (i) keep the toilet clean and hygienic, (ii) avoid its contents making nearby water unfit to drink, and (iii) how you should use the toilet in an hygienic way.

. Project. Safe water in the city.

Source: Philippines. University of the Philippines Institute for Science and Mathematics (ISMED). Water in Your Community Manila: ISMED 1984 p 19.

Can you tell how the persons in the picture make safe water from the faucets unsafe for drinking?

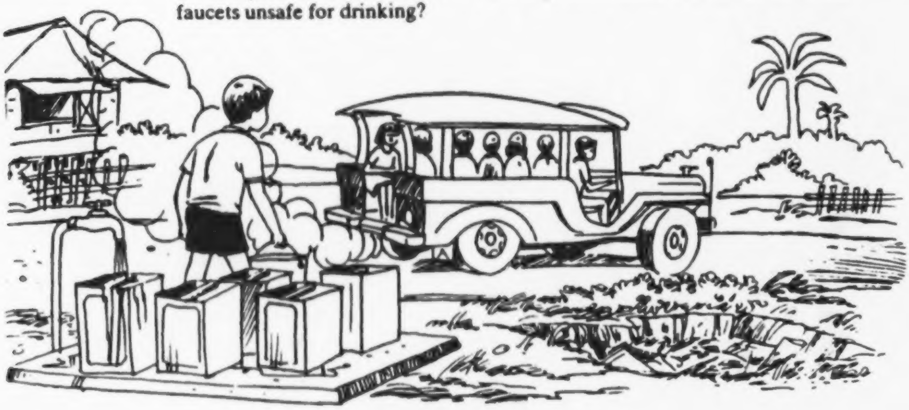


Figure 24

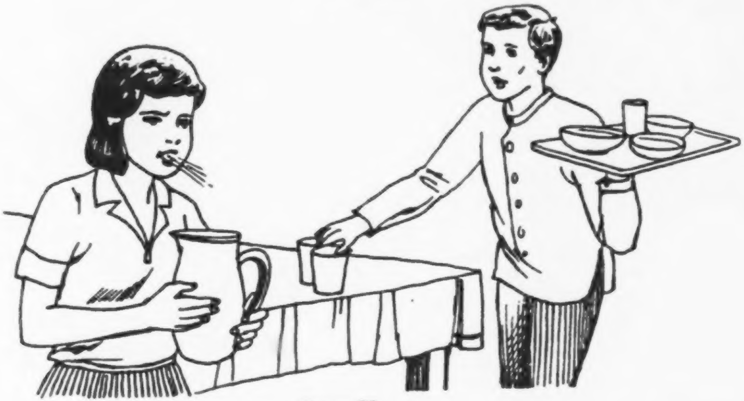


Figure 25

It is not enough that we have safe water from faucets. We should also handle it with care.

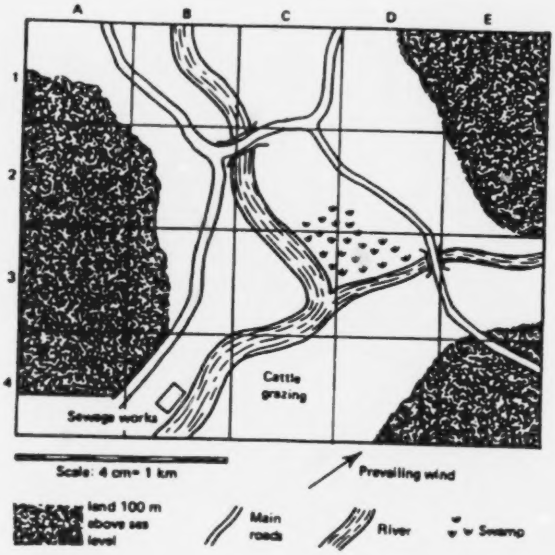
You can help inform people that they must use sanitary ways of handling water to keep it safe for drinking.

. Test Questions

1. (a) Make a large labelled diagram to show the structure of a septic tank.
   (b) Explain the part played by micro-organisms in making a septic tank work.
   (c) Why is it important for a septic tank to be made of brick or concrete, with heavy covers?
   (d) Why is a septic tank preferred to a simple pit latrine?

2. One family living in a countrydistrict may dispose of sewage in a pit latrine. This method is not suitable for a community of 15,000 people living in a town.
   (a) Use diagrams to help you to explain a method of sewage disposal suitable for such a town (e.g. the activated sludge method or the biological filter method).
   (b) What reasons can you suggest for a large community using this method rather than pit latrines?
   (c) Why must sewage be disposed of properly?

3. Study the following map.


A
B
C
D
E
1
2
3
4
Cattle grazing
Sewage works
Scale: 4 cm= 1 km
Prevailing wind
land 100 m above sea level
Main roads
River
Swamp

The map above shows an area of 5 square kilometres in a tropical country. Each square on the map can be identified by using a number and a letter. For example, the main river flows from square B1 to square B4, and is joined by a small river in the square C3.

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(a) What work would a local authority have to carry out to make the area C3 and D3 safe for people to work there? Give your reasons.

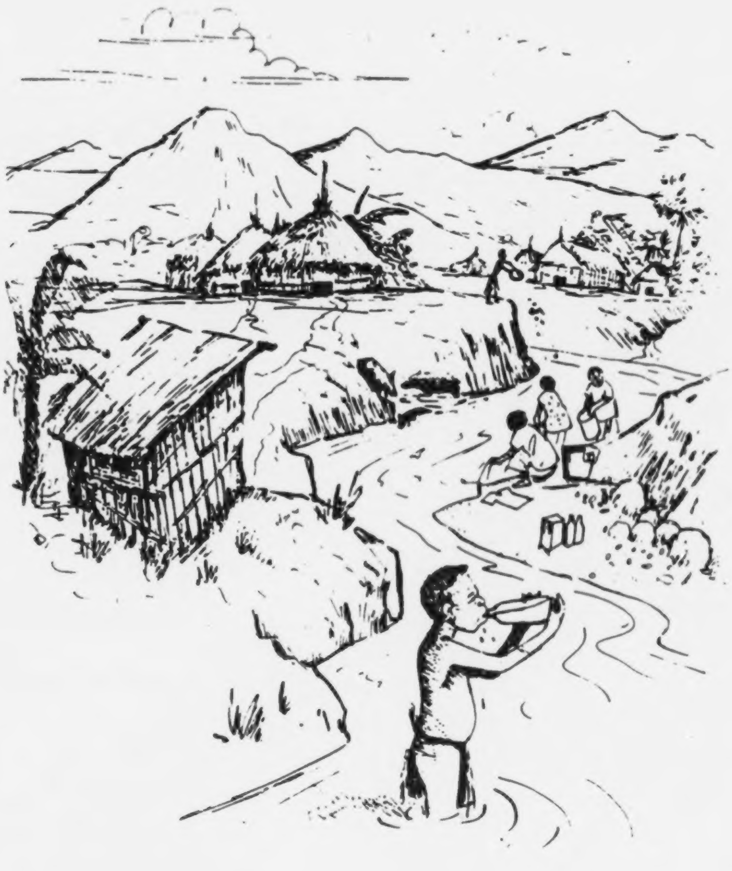
(b) Suggest reasons for making a housing site in the area marked by the squares A1, A2 and A3 rather than in the area D1 and D2.

(c) Where would a waterworks be best sited? Give reasons.

(d) What reasons are there for siting a refuse tip in the region marked E2?

Source of Test Questions 1, 2 and 3. Phoon, W.O., Chew, P.K., and Goh, E.H. Comprehensive Human and Social Biology Third Edition. Singapore: Federal Publications 1986 p 289

4. Study the following picture of people using water from a small stream.



Source of picture: Department of Education Papua New Guinea. Science Microbiology Teachers Guide Grade 10 Unit 3. Boroko: Ministry of Education 1988 p 147

Answer the following questions

i) List the four ways the stream is used by the village.
ii) Describe three things shown in the picture which make it unhealthy for the boy to drink the water.
iii) What should the villagers do to correct these three problems?

6.6 The Issue of Personal Development

i) Rationale

Most school programmes in biology, especially those with an emphasis on human biology, have included a treatment of biological aspects of human development. Areas frequently covered include (i) human reproduction (ii) prenatal development and birth (iii) growth to adulthood (iv) the characteristics of adolescence, including puberty and (v) physiological aspects of the human life cycle.

These aspects are central to any more extended treatment of personal development, but in a programme with a strong commitment to social issues, they should be seen only as starting points. It is clear that some social issues stem directly from these basic more traditional topics. Some which come to mind include healthy physical development; sexual behaviour and codes; sexuality; parenting and the issue of the aged in society.

More indirectly, modern socially oriented biology programmes could also deal with key psychological and sociological aspects of personal development (13). These could include issues such as self awareness and the development of an autonomous personality with some treatment of issues such as locus of control; changes in ability; changes in attitudes and interests; cognitive style; self esteem and other aspects of a positive self image; and growth of individuals to their full potential.

Personal development studies within biology should be strongly future oriented. Availability of popular books such as Sheehy's Passages (14) makes it possible to review aspects such as changing social tasks and roles across defined stages or phases of life; and changes in "stance" or general orientation to life in general. Of course since these events are in the future of the school-age learner, they should be dealt with broadly and in a preparatory manner. Life planning techniques could be introduced and questions of life goals, and life styles reviewed and analysed.

Family life issues and vocational issues are of course aspects of personal development. These topics, however, are very broad and are treated in separate sections. Also because of their stronger normative attributes they are dealt with in Chapter 7 rather than in this chapter which focuses more sharply on basic personal needs.

This broadening of school biology to include psychological and sociological aspects of personal development may be seen by some as going well beyond the scope of the subject within the present school curriculum. The point is, however, that these broader issues of personal development are the very things necessary to help an adolescent learner pass through the difficult transition to successful adulthood. An important aim of secondary education should be to ensure that school leavers continue to learn and grow in overall effectiveness throughout life. Only then will personal development transfer to positive national development. Unfortunately at present, few school systems deal with these aspects partly because there is no obvious "subject niche" for them in the curriculum. Modern socially oriented biology programmes do provide a niche since the starting point from biological aspects of the human life cycle provides a firm foundation.

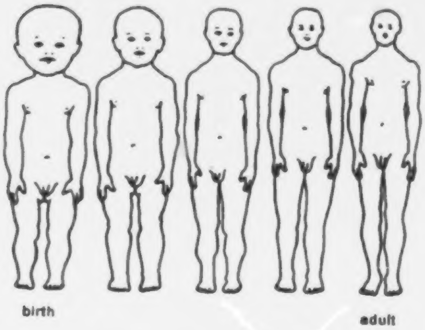
ii) Examples of Relevant Content

Example 6.16: Growth in human babies

School System: Australia. New South Wales Higher School Certificate Biology.
Approach: Study of public records of infant growth rates
Source: Cohen, David; Hill, Jennifer; McDonnell, Kevin, and Meyer, G. Rex Biology Practicals for Senior Students. Melbourne: Heinemann Educational Australia 1989 pp 56-57

CD15 Growth in human babies

As an organism grows there is an increase in size and a change in form or proportion of the various parts. This is obvious when the proportions of the human body in postnatal life are compared (see diagram).



Environmental factors affect the growth of an individual but there is a set pattern of growth for any species.

INQUIRY

To investigate the rate of increase in weight, heel-crown length, and head circumference in a child's first year.

PROCESS OBJECTIVES

By the end of this activity you should be able to:

1. use information obtained from the Department of Health to draw conclusions about growth in human babies
2. construct graphs to show differences in growth rates.

MATERIALS

record cards from Baby Health Centre

graph of normal growth for first twelve months

PROCEDURE

A From your own parent or guardian, a neighbour or a friend, obtain a record card for a child who has attended a Baby Health Centre for at least twelve months. This card carries information as to the age and weight of the baby as well as the heel-crown length, and crown circumference, at ages of approximately one week, three months, six months, nine months, and twelve months.

B Construct an age/weight graph for the baby, and compare it with the normal graph supplied to Baby Health Centres by the Department of Health. You will need to visit a Baby Health Centre to see such a graph and ask the nurse-in-charge.

C On the same graph plot the age/heel-crown length and age/crown circumference. You will obviously need three different scales on the y-axis.

D If record cards for several babies can be obtained, average the monthly weight and plot these on an age/weight graph. Compare this graph with that constructed for one baby and with the normal graph supplied by the Health Department.

QUESTIONS

1. What is the reason for the shaded area on the normal graph supplied by the Health Department? What implications can be drawn from this?
2. Explain any differences you observe in rate of increase in heel-crown length when compared with rate of increase in crown circumference.
3. Do babies who weigh less than the normal birth weight when born always remain below the normal weight? Explain your answer. (The nurse at the local Baby Health Centre can help with information on this topic.)

FURTHER INQUIRY

1. Try to obtain measurements of the length of limbs and trunk of babies and childen of various age, so that observation can be made of limb proportions at various ages.
2. Find information on the growth rates of babies of different human populations and discuss your findings.

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Example 6.17: Physical growth of adolescents

School System: *Australia: New South Wales Higher School Certificate Biology*
Approach: *Collection of growth data by survey method*
Source: *Cohen, David; Hill, Jennifer; McDonnell, Kevin, and Meyer, G. Rex* *Biology Practicals for Senior Students.* *Melbourne: Heinemann Educational Australia 1989 pp 57-58*

CD16 *Growth in adolescence*

Variations exist in human populations just as in others. It is possible to recognize many characteristics which vary, such as height, weight, hair colour, etc. but there are a great many that are not immediately apparent. In this investigation you will have the chance to gather a relatively large amount of data about height and weight variations and then use it to make generalizations.

INQUIRY

To examine the relationships between age, height, and weight in the population of Australian secondary school pupils.

PROCESS OBJECTIVES

By the end of this activity you should be able to:

1 carry out a survey to obtain information from pupils
2 construct and interpret graphs of pupils' height and weight.

MATERIALS

metre ruler
bathroom scales
graph paper

PROCEDURE 1

A Working with a partner, arrange to have the members of your class list their ages and record their heights and weights.

B Your teacher should then arrange to have the remainder of your year level come to a selected spot during a recess whereupon the above information will be collected for each person.

C Using the same procedure, extend the survey to cover all other classes in the school.

PROCEDURE 2

Working with the data you have collected, construct graphs of:

1 age versus weight (boys)
2 age versus weight (girls)
3 age versus height (boys)
4 age versus height (girls)

PROCEDURE 3

The tables reproduced here should be used to establish the medians and the range in which 80% of the population is to be found. Weights are expressed in kilograms; heights in centimetres.

Age/weight boys

Age	Median	80% range
10	30.5	23.5–37.5
11	35.0	27.1–42.9
12	39.5	30.6–48.2
13	44.1	34.2–54.0
14	48.6	38.3–58.9
15	53.1	42.5–63.7
16	57.7	47.4–68.0
17	60.8	52.1–69.5

Age/weight girls

Age	Median	80% range
10	31.5	24.8–38.2
11	34.8	26.4–43.2
12	39.0	29.4–48.6
13	44.3	33.6–55.0
14	50.1	39.4–60.8
15	53.2	44.3–62.1
16	55.1	46.4–63.8
17	56.5	47.7–65.3

Age/height boys

Age	Median	80% range
10	138.3	131.2–145.4
11	142.7	134.9–150.5
12	147.0	138.2–155.8
13	153.4	143.3–163.5
14	160.6	150.2–171.0
15	166.8	157.1–176.5
16	171.7	163.3–180.1
17	174.3	166.7–181.9

Age/height girls

Age	Median	80% range
10	137.5	130.2–144.8
11	141.8	133.4–150.2
12	148.5	138.7–158.3
13	154.1	144.8–163.4
14	158.2	150.8–165.6
15	161.1	153.8–168.4
16	162.9	155.3–170.5
17	163.8	155.8–171.8

QUESTION

1 How many pupils in your school fall within the 80% range for height and weight?

FURTHER INQUIRY

It is interesting to compare the growth curves of adolescent boys and girls. Once again using the tables, construct a growth curve for boys (height and weight) and girls (height and weight). What comments can you make about them?

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Example 6.18: Development of self confidence and social skills

School System: Norway. Trysil Ungdomsskole
Approach: Teachers notes for a school "adventure" camp
Source: Trysil Ungdomsskole "Trysil Projekt" in Organization for Economic Cooperation and Development (OECD) International Project Exhibition: "Cycles" "The Daily Life of the Family M" (OECD Project Environment and School Initiatives) Vienna: OECD Center for Educational Research and Innovation in association with the Austrian Federal Ministry of Education, Arts and Sports in Cooperation with the Upper Austrian School Board, 1988 pp 68-69

TRYSIL UNGDOMSSKOLE

Trysil Projekt

We have approximately 300 pupils at our school, age group 13 to 16. The school is centralized and we have most of the children of that age in the community at our school.

"The Trysil Project" is a programme to develop Trysil Secondary School with special focus on the position of the school in the local community. We want our pupils to learn about the nature surrounding them, providing for an understanding and respect for life and the obligation to protect and care for our living environment. Very many topics are part of "The Trysil Project". Here I want to present three of the topics.

"The Camp School" is a course offered to all the 8-graders and all the teachers at the school. The course is a survival camp for three days in the wilderness. The camp consists of canoeing, camping and cooking on fires. The aims for The Camp School are:

Social aims:
- Strengthen the social well-being between students and teachers.
- Provide for the students' ability to co-operate and take responsibility under unfamiliar conditions.
- Provide for special qualities in the students that are needed for the situation.

Knowledge:
- Provide for understanding and knowledge of the complicated interactions in nature through: observation, investigation and study of geology, biology and ecology.
- Provide for an understanding of the ecological consequences of human interaction with nature.

Skills:
- Give basic training and skills in survival fitness.
- Experience the diversity of nature through senses and feelings.

Attitudes:
- Provide for awareness to nature, ecological sensitivity and will to protect nature and our living environment.

"Hunting, Fishing and Outdoor Life" is a voluntary course for the 9-graders, and takes place one day a week during the school year. This course is separate from the ordinary lessons and has its own syllabus and schedule.

The aims for the "Hunting, Fishing and Outdoor Life" course are:

Social aims:
- Provide for social well-being and stimulate non-motivated students in work with untraditional school subjects.
- Develop the students' abilities for a future occupation.

Skills and knowledge:
- Skills in traditional handicrafts within hunting and fishing.
- Instruction in hunting and fishing techniques.
- Instruction in shooting.
- Stimulate the students' abilities and knowledge in experiencing and understanding nature and the ecological processes and balances.

"Stone Grinding" is a voluntary course offered to pupils in 8th or 9th grade two lessons a week throughout the school year. As their material the pupils use stones found in Trysil or stones from other parts of the world. On their self built equipment they cut, shape and polish the stones to be used in a necklace or as a trinket fastened to a pin.

Stonegrinding is a popular hobby among our students. They develop an eye for what kind of stones they may find in nature to use for stonegrinding, and they are also able to make some money on their hobby. This is a course where non-theoretical students very often do well, and it improves their self-confidence.

Conclusion: Through "The Trysil Project" our school tries to offer our students activities which are not always too closely related to what one normally thinks of as classroom activities. In that way we hope to give everyone something in which he or she will succeed. In that way we hope to help the students create, develop and strengthen a positive self image. We want our students to feel that they are important parts of the society and community in which they live.

Example 6.19: PPP - Personal project planning

School System: -
Approach: Personal planning for setting and achieving a specific short-term goal by individual students
Source: Suggestion by author

A Personal Plan

Set yourself a personal goal to be achieved over the next six or twelve months. The goal must have something to do with living things. Here are some suggestions:

1. Establish a small garden to sell vegetables or flowers to give you more pocket money.
2. Make a small balanced freshwater aquarium to keep live fish.
3. Write a booklet on a biology topic of your interest.
4. Organize a "clean up" campaign to remove rubbish from a local park.
5. Make a collection of shells or other items from the plant or animal kingdoms.
6. Make ornaments or jewellery from plant or animal products for sale at a school fete or to give you more pocket money.
7. Put together a portfolio of paintings or drawings of plants or animals.

Plan how you could achieve this goal. Do this by drawing up a table something like the one given below:

Week	Target Step	Resources Needed	Cost	Comments
1				
2				
3				
4				
5				
6				
7				
8				
51				
52	GOAL ACHIEVED			

Total = $ ________

In the second column write down step by step what you should do over the year (or less) to achieve your goal. There may be only one or two steps spread across the weeks or there may be many more. In the third column list the materials and other resources you will need at each step - and don't forget to include any people you may need as advisers or helpers. The fourth column is for the listing of any costs involved at each step. Use the last column to jot down any notes or ideas which may help you achieve each step.

Over the next twelve months try to implement your project plan and be prepared to modify the plan if for any reason you cannot meet any of the target steps.

Example 6.20: Planning for the future

School System: -
Approach: Project for school leavers creating awareness of the need to broadly plan a possible future life
Source: Suggestion by author.
First two columns of table based on Cross, K. Patricia Adults as Learners. San Francisco: Jossey-Bass 1981 pp 174-175

Thinking About Your Future Life

In the following table the first column shows what most people do at various phases of their adult lives. The second column lists what happens to most people at each phase of life. The information is based on what happens in the United States of America. Read through the table carefully. In the third column write down what you think you would like to happen at each phase of your future life.

A Life Planning Table

Phase and Age	What Most People Do	What You Would Like to Do
Leaving Home 18-22	Leave home Establish new living arrangements Enter college Start first full-time job Select future husband or wife	
Moving into Adult World 23-28	Marry Establish home Become parent Get hired/fired/quit job Enter into community activities	
Search for Stability 29-34	Establish children in school Progress in career or consider change Possible separation, divorce, re-marriage Possible return to school	
Becoming One's Own Person 37-42	Important promotion Break with person/s who helped you in the past Responsibility for three-generation family; i.e. growing children and aging parents For women: children grown up and left home; enter career and education	
Settling Down 45-55	Top of career Become guide or helper for younger people Launch children; become grandparents New interests and hobbies Physical limitations Active participation in community events	
Growing Older 57-64	Possible loss of mate Health problems Preparation for retirement	
Life Review 65+	Retirement Physical decline Change in finances New living arrangements Death of friends/husband or wife Major shift in daily routine	

Example 6.21: Life line planning

School System: -
Approach: *Project for school learners to heighten awareness of need to set and achieve goals throughout life*
Source: *Suggestion by author*

Achieving the Best from Life

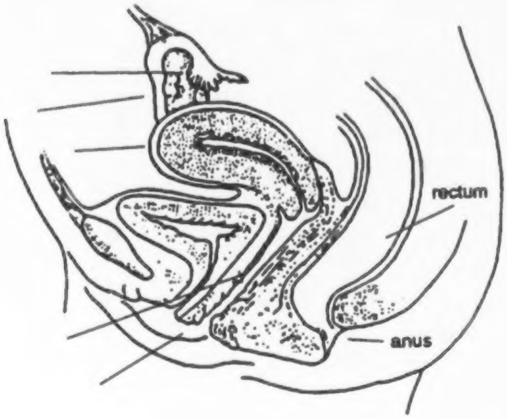
When you leave school your whole adult life is ahead and you must be careful to make the most of it. One thing that is helpful is to try to plan in very general terms the things you would like to achieve. One technique is to draw up a life-line and to set general goals to be achieved at various ages. The following scheme gives you some idea how you could do this but you could use any headings you feel would be best for you.

Age in Years	Qualifications Obtained	Areas of Knowledge and Skill Achieved	Family Events	Employment	Hobbies and other Leisure Events
15					
16					
17					
.					
.					
.					
.					
.					
.					
65					

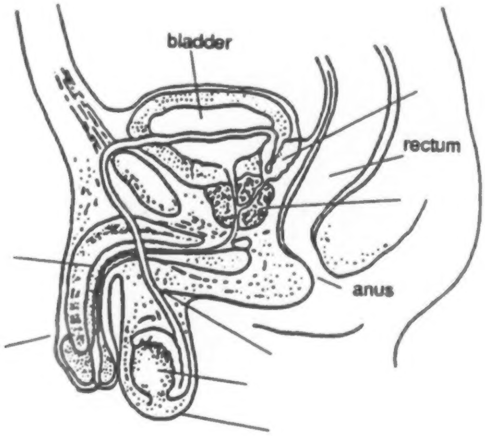
Of course it is not possible to actually foresee the future or to really plan out exactly what may happen. But if you do set broad goals and be flexible and adaptable in modifying your plan, then it is likely that you will achieve more and have a happier and more fulfilling life.

iii) Examples of Project and Test Questions

1. Label the diagram below to show the structure of the female reproductive system of humans. Indicate on the diagram where cell division to produce sex cells occurs.



2. Label the diagram below to show the structure of the male reproductive system of humans. Indicate on the diagram where cell division to produce sex cells occurs.



Source of Test Questions 1 and 2
Hill, Jennifer; Meyer, G. Rex; Cohen, David, and McDonnell, Kevin Excell HSC Biology. Sydney: Pascal Press 1990 p 98.

3. Read the following text and then answer the questions given below.

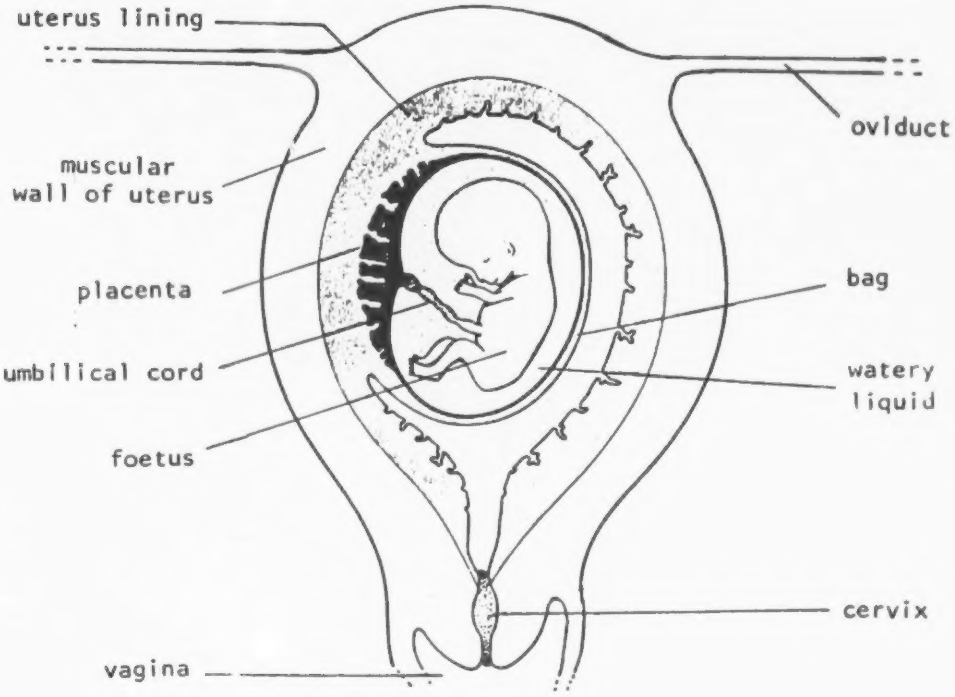
How a Baby Develops

The stages that are necessary for sexual reproduction are:

(i) production of sex cells;
(ii) mating;
(iii) fertilization;
(iv) development of the zygote into an embryo;
(v) formation of a new individual.

In humans, the sex cells are produced in the ovaries and in the testes.

During mating, the male puts his penis inside the female's vagina. Many millions of sperm cells leave his body and enter the female. They swim through the uterus into the oviducts. If an egg cell is present, one sperm cell will join with it (i.e. fertilize it). The zygote moves towards the uterus and begins to develop into an embryo which fixes itself to the lining of the uterus. A special structure, called the placenta, develops from the embryo. The embryo is joined to the placenta by the umbilical cord. Through this the embryo receives food and oxygen from the mother's blood. As the embryo begins to grow, the uterus also grows. The embryo becomes a foetus, and after about twelve weeks the pregnant woman (i.e. one that has a baby growing inside her) notices that her abdomen and breasts are becoming bigger. The diagram below shows what the foetus looks like after it has been developing for about 3 months.



The bag of watery liquid protects the foetus and absorbs shock.

Gradually the foetus grows and develops and becomes more human in appearance. After 38 weeks, the foetus is ready to be born.

The muscles of the uterus begin to contract at regular intervals and gradually open the cervix so that the baby's head can pass through. This stage usually takes many hours. When the cervix is open, other muscles in the uterus push the baby out through the vagina. The umbilical cord is tied and cut and the baby is now a separate individual. The placenta and cord then come out of the vagina. They are sometimes called the "after-birth".

The mother begins to make milk in her breasts to feed her baby. She will feed the baby on milk for about two years, but will continue to look after the child for many years.

Answer the following questions.

1. How do sperms get inside the body of the female?
2. How many sperms are put inside the female's body?
3. How do the sperms reach the eggs?
4. Where does fertilization take place?
5. Where does the embryo develop?
6. How does the embryo get food and oxygen?
7. Why does the foetus develop inside a bag of watery liquid?
8. How long does the foetus develop inside the mother's body?
9. From which part of the body does the baby leave the mother?
10. What is done to the umbilical cord when the baby is born?
11. What is the "after-birth"?
12. How does the mother feed her baby?
13. For how long do humans care for their young?
14. Write down three ways in which humans care for their young.

Source of Test Question 3: Ministry of Education Papua New Guinea Science Growth and Reproduction Teachers Guide Grade 8 Unit 5. Boroko: Ministry of Education 1986 pp 98-100.

4. Study the following text and then answer the questions which follow:

Suppose you were a single person earning $9,600 per year after taxes ($800 per month). How would you spend your money? And how would your decisions about spending your income reflect your values? Let's look at how two people spend their money. Each of these people earns $9,600 per year.

Figure 22 shows Lucy's budget. Lucy attends college in the evening and works part-time for the telephone company during the day. She shares an apartment with a friend. She rides the bus to work and to school. Lucy's favourite hobbies are cooking, tennis, and horseback riding.

Harry's budget is shown in Figure 23. Harry is employed full-time as a secretary-receptionist in a doctor's office. He recently purchased a used sports car, which he is paying for with a four-year loan at 11 percent interest. He usually eats out and prefers having an apartment of his own. Harry would like to save for a vacation in the Bahamas but, so far, has been unable to do so.

In what ways are Lucy's and Harry's different life-styles expressed in their budgets? How are their values different?

Now prepare your own budget using a form like the one in Figure 24. Assume that you also earn $9,600 per year after taxes. If you are not already working, imagine that you are working at a job you would like to have. This can be either a full-time or part-time job, depending on what you think you will earn. If you are currently employed, you may wish to base your budget on what you actually make rather than the $9,600 figure.

After you complete your budget, consider the following questions. How does your budget reflect your values? Is your budget adequate for your needs? If not, how is it inadequate? How do your values differ from those of Lucy and Harry? How are those differences reflected in your budget?

Lucy's Budget

Item	Amount	
	Per month	Per year
Food and housekeeping supplies	$ 120	$1,440
Housing	150	1,800
Utilities	75	900
Clothing	50	600
Medical care (dentist, doctor)	40	480
Insurance (life and health)	50	600
Personal care (haircuts, toothpaste, makeup)	50	600
Transportation (bus fare, gasoline, insurance)	75	900
Entertainment	30	360
Education	85	1,020
Books and magazines	50	600
Charity	10	120
Savings	15	180
Total	800	9,600

Figure 22.

Harry's Budget

Item	Amount	
	Per month	Per year
Food and housekeeping supplies	$ 210	$2,520
Housing	260	3,120
Utilities	70	840
Clothing	15	180
Medical care (dentist, doctor)	15	180
Insurance (life and health)	15	180
Personal care (haircuts, toothpaste, etc.)	15	180
Transportation (bus fare, gasoline, insurance)	75	900
Car payment	105	1,260
Entertainment	10	120
Education	—	—
Books and magazines	10	120
Charity	—	—
Savings	—	—
Total	800	9,600

Figure 23.

Your Budget

Item	Amount	
	Per month	Per year
Food and housekeeping supplies	$ ________	$ ________
Housing	________	________
Utilities	________	________
Clothing	________	________
Medical care (dentist, doctor)	________	________
Insurance (life and health)	________	________
Personal care (haircuts, toothpaste, makeup)	________	________
Transportation (bus fare, gasoline, insurance)	________	________
Entertainment	________	________
Education	________	________
Books and magazines	________	________
Charity	________	________
Savings	________	________
Total	800	9,600

Figure 24.

Source for Test Item 4: Biological Sciences Curriculum Study Investigating the Human Environment: Land Use. Colorado Springs: BSCS 1984 pp 55-56

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6.7 The Issue of "Human Dignity"

i) Rationale

The concept of human dignity, centred as it is on recognising the worth of every individual, has its biological basis in the genetics and evolution of individual differences. Cultural evolutionary aspects add further to the concept and it becomes associated with constructs such as freedom and the rights of the individual.

The biological basis of human rights is thus something that should be dealt with in some detail within a course of secondary school biology. M.J. Frazer and A. Kornhauser claim, for example, that "every opportunity should be taken in science education to explain and develop proper attitudes towards human rights. In science lessons an objective approach will overcome the pseudo-scientific basis of prejudice, intolerance and racialism" (15).

An individual's right to political, social and economic freedom must be understood and respected if any community is to develop as a democratic and forward moving society. In the area of social freedom, freedom of speech, of publication, of religion, of assembly, freedom to study and to learn, freedom to own property, and freedom of access to the due processes of the law all have adaptive biological significance as well as immediate social implications.

Science courses have just as much responsibility as other subjects to remind pupils of manifestos such as the 1948 United Nations Declaration of Human Rights with its hope that humankind will come to respect the rights and dignity of all individuals, and basically to accept that all peoples have the right to life, liberty and security.

The United States educators Lee and Charlotte Anderson go so far as to say that this type of approach should provide the basis for what they designate as the five major goals of the schools. These goals are (16):

> "1. To develop students' understanding of themselves as individuals.
>
> 2. To develop understanding of themselves as members of the human species.
>
> 3. To develop students' understanding of themselves as inhabitants and dependents of planet Earth.
>
> 4. To develop students' understanding of themselves as participants in global society.
>
> 5. To develop within students the competencies required to live intelligently and responsibly as individuals, human beings, earthlings, and members of global society."

It is clear that many aspects of the above goals can be achieved through a socially oriented programme of school biology. The genetical basis of variability and individuality; the origin of differences due to biological and cultural evolution and the ecological study of adaptations each provide a framework for more general social considerations involving the concept of human dignity. Possible links between biological and societal aspects of these ideas have been highlighted in the following table proposed by Dr Stuart Spicker of the United States (17).

KNOWLEDGE OF HUMAN HEREDITY	HUMAN CONDUCT AND DECISION MAKING
WHAT DO I KNOW?	WHAT OUGHT I TO DO?
1. Variability	1. Tolerance vs. intolerance
2. Individuality	2. Personal responsibility for one's life vs. irresponsibility
3. Adaptation	3. Social responsibility for new knowledge and the survival of the species vs. egoism and the danger of extinction

What these considerations imply of course, is that concepts such as variability, individuality and adaptation must not be treated in abstract using only the classical examples of Mendel's experiments with peas or studies of speciation in horses or the adaptive evolution of the invertebrates. The approach should be based on studies of the human species. What is required is that a connection be made between these concepts and socially determined concepts such as basic human freedoms and human rights and respect for the worth of the individual.

Another aspect of human dignity which could be developed within the context of school biology is the issue of communication. The development of tolerance through clear and unambiguous coding, transmission and receipt of messages and the value of respecting the views of others contribute to our understanding of the worth of individuals.

Example 6.22: Human and cultural variation

School System: *Australia: New South Wales senior secondary schools*

Approach: *Library research project on the characteristics of different human groups throughout time*

Source: *Cohen, David; Hill, Jennifer; McDonnell, Kevin, and Meyer, G. Rex* Biology Practicals for Senior Students. *Melbourne: Heinemann Educational Australia 1989 pp 152-153*

EA 6-10 Humans and cultural variation

Ideally, this investigation would be carried out as a field study. You might tour widely and visit many lands and study people and their culture at first hand. This type of investigation, although of prime importance in a scientific investigation of human culture, poses certain practical difficulties. Even for those who have the time and the means to travel in this way it is becoming increasingly difficult to study the culture of some of the smaller racial groups. Distinctive cultural features are being lost. This activity is largely a library research project although you may be able to gain information by interviews with any people with whom you have contact, who have their origins in other lands or have travelled widely.

INQUIRY

To examine the cultural variations present in the different groups of humans and some of the factors responsible for these variations.

PROCESS OBJECTIVES

By the end of this activity you should be able to:

1 carry out a thorough research activity on different groups of humans

2 summarize and present information at a seminar.

PROCEDURE

The silhouettes shown in the table opposite represent the facial features of the following groups; Asiatic, Indian, African, European, Australian Aborigine, Melanesian, American Indian, Polynesian.

Organize your class group to undertake research into aspects of the habitat and culture of each of these groups under the following headings:

1 Climate

2 Environment

3 Housing

4 Clothing
5 Food gathering
6 Hunting implements
7 Cooking vessels
8 Popular art and music forms

Each student should carry out a thorough library survey of at least one (but no more than two) of these groups and present her or his findings to the rest of the class in an organized lecturette session. The activity should conclude with each student drawing up a table summary arranged as suggested here.

Group	Feature		
	climate	environment	housing
Asiatic			
Indian			

FURTHER INQUIRY

The following questions should stimulate some thought-provoking discussion in your seminar group:

1 What effect has climate had on the variation in culture?

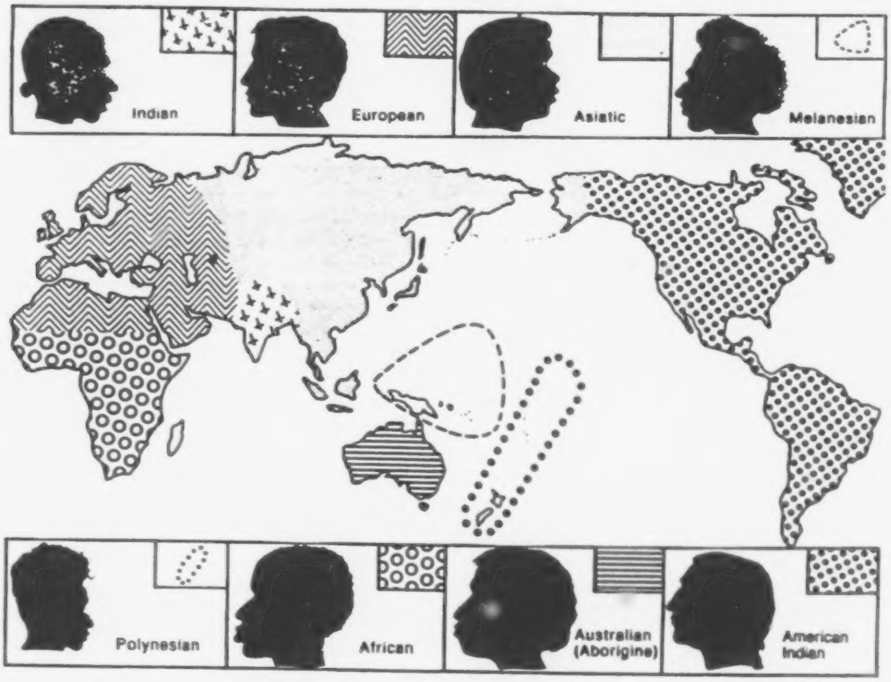
2 How has the biological component of the environment affected human culture?

3 What has been the impact of increased communication and travel on cultural variation?

4 What effects is tourism likely to have on cultural groups which exist today?

5 Do you think any steps should be taken to preserve the cultures of smaller ethnic groups? Why? If so, what steps should be taken?

Distribution of human populations



Example 6.23: Speciation of humans

School System: Australia New South Wales senior secondary schools
Approach: Library assignment to foster belief in the unity of humankind by a study of distribution and potential speciation
Source: Cohen, David; Hill, Jennifer; McDonnell, Kevin, and Meyer, G. Rex Biology Practicals for Senior Students. Melbourne: Heinemann Educational Australia 1989 p 155

EA 6–12 *The speciation of* Homo

Possibly there were human-like groups on Earth around 15,000,000 years ago and if these were geographically (and thus reproductively) isolated, it could have led to the development of more than one species of human-like organism over a very long period of time.

During the course of human evolution most of these races were not successful in adapting for survival and have since become extinct species. The species *Homo sapiens* was outstandingly successful and has been the only surviving *Homo* species for tens of thousands of years.

The map accompanying this exercise shows the distribution of the major types of *Homo sapiens* before mass population movements during the last 4000–6000 years.

If mass population migration never occurred it is fair to suggest that *Homo sapiens* might have evolved in several different directions to form new species of *Homo*.

INQUIRY

To investigate why the genus *Homo* has not evolved to form a number of distinct species.

PROCESS OBJECTIVE

By the end of this activity you should be able to:

1 organize research and discussions to answer questions on the speciation of humans.

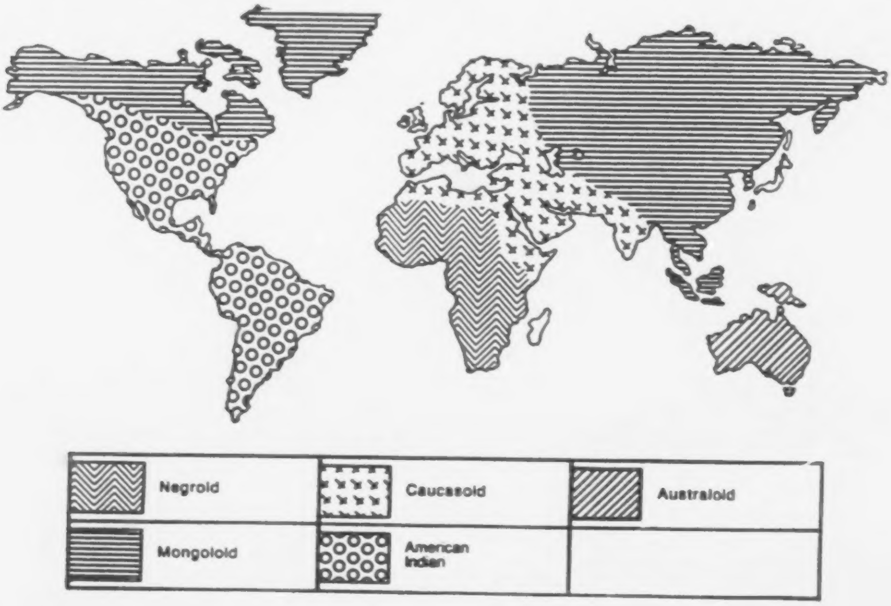
MATERIALS

access to library references on culture, technology and speciation.

PROCEDURE

Spend one or more class periods in the library, survey available literature for background information about the topic suggested, and then discuss the hypothesis that 'The development of culture and technology is preventing the formation of new *Homo* species'. Your discussion could take the form of a written essay or a seminar session with others who have made a similar inquiry.

Distribution of human populations 4,000–6,000 years ago



Example 6.24: Religion, culture and human evolution

School System: Australia, New South Wales senior secondary schools

Approach: To improve awareness of the origins of cultural difference and to foster tolerance and understanding of the views of others through a library project.

Source: Cohen, David; Hill, Jennifer; McDonnell, Kevin, and Meyer, G. Rex Biology Practicals for Senior Students. Melbourne: Heinemann Educational Australia 1989 p 154

EA 6–11 Religion, culture and human evolution

INQUIRY

To investigate the extent to which religious beliefs have affected the physical and cultural evolution of humans.

PROCESS OBJECTIVES

By the end of this activity you should be able to:

1. use available information to research the religious beliefs and historical aspects of religion in different parts of the world
2. present a five minute talk as a tape recording.

PROCEDURE

A Use library resources to obtain information about the concept of a deity (if any) held by each of the religious groups indicated in the map. Produce a chart/summary of these findings.

B Refer to newspaper and journal articles and modern history references to obtain information about:

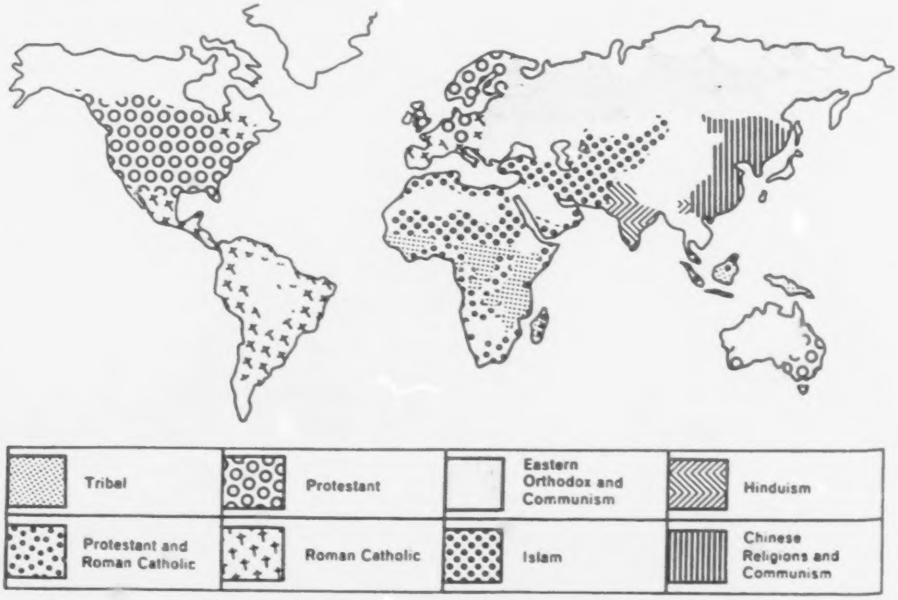
1. the formation of India and Pakistan as different countries
2. the formation of the state of Israel after World War II
3. the group known as 'Mormons' located around Salt Lake City in Utah, U.S.A.

Use your findings as the basis of an essay in which you support or reject the hypothesis that 'religious barriers have played a part in establishing various human groups and micro-groups'.

C Use library reference material or interviews with persons of different racial origins to yourself to determine the extent to which religious beliefs affect family structure in the main racial groups of the earth.

Present your findings as a five minute talk recorded on tape which can be played to your classmates as part of an integration activity.

Areas of dominance of main religions of the world


Tribal
Protestant
Eastern Orthodox and Communism
Hinduism
Protestant and Roman Catholic
Roman Catholic
Islam
Chinese Religions and Communism

Example 6.25: Concept of human freedom as a product of evolution

School System: -
Approach: *A class discussion on the origin of modern views about freedom of the individual.*
Source: *Suggestion by author*

Class Project on Human Freedoms

Here is a list of freedoms which are now more or less regarded as the social "rights" of every human being. They are expressed in many political manifestos, statements by the United Nations and in the constitutions of many countries.

Freedom of Speech
Freedom of the Press
Freedom of Religion
Freedom of Assembly
Freedom to teach and learn
Freedom of access to due processes of the law

Step I. Working by yourself think through how you and your parents have been able to exercise each of the above freedoms in your lives. There is no need to write anything down. This is just to stimulate your personal and private thoughts.

Step II. Form discussion groups of five. Try to work out how much influence the following biological principles may have been involved in the emergence of the ideas of freedom.

Inheritance of individual differences and individuality
Genetic variation
Biological evolution
Ecological adaptation
Cultural evolution

Step III. Elect a spokesperson and report your findings to the class as a whole.

Example 6.26: Listening skills

School System: Republic of South Africa: Natal Education Department
Approach: Increased sensitivity to others by means of group activities to enhance listening skills.
Note: While this material was initially developed for younger pupils it could be readily adapted for the secondary school.
Source: Natal Education Department Family Life Education (Bulletin 45) 1988 pp 130-132

Listening Skills

Overall Aim: To develop basic listening skills

OBJECTIVES	CONTENT	ACTIVITIES
i. To experience the frustration of not being listened to. ii. To become aware of one's own weaknesses in this area.	Identification of feelings when continually interrupted in a conversation.	Games as a medium for experiential learning. (This session will be a series of games designed to make each individual experience frustration as a result of not being listened to. Hopefully, having experienced the frustration they will become aware of their own weaknesses in this area.) GAME 1 1. Divide children into pairs. 2. Each pair to name itself A and B. 3. Call all A;s together and give instructions as follows - "You are to talk about your favourite activity for 3 minutes to B". 4. Call B's together. Instruct them to interrupt A while he's talking, as often as he can in three minutes.

5. Allow activity to proceed for three minutes.
6. Allow time for general sharing of feelings, resulting from the experience of being interrupted. It helps to give them a sentence stub e.g. "I felt..." At this stage most children will share a judgement, e.g. "I felt that 'A' was being rude" in preference to a feeling (e.g. "I felt angry OR frustrated or annoyed or unimportant etc. ...") Don't correct at this stage, rather allow free-flow of communication with you and group.

Identification of 2 basic rules:
(a) a good listener does not interrupt
(b) A good listener looks at the speaker

GAME 2

1. Re-group in pairs (using different children).
2. Name A and B.
3. Give B instructions - "You must tell 'A' what you (child) did over the weekend (for two minutes)."
4. A's instructions: Do not look at 'B' at any stage while he's speaking to you.
5. Time for two minutes. Share feedback from experience. ("I felt ...")

Conclusion

Today we've learned quite a lot about listening. What have we learnt?
(a) A good listener does not interrupt.
(b) A good listener looks at the speaker.

iii. To develop basic listening skills.	The concept of skill rating on a continuum of 1-10.	INTRO: Who can tell me what we've learned so far about listening? Allow children to contribute from previous lessons. Give out slips of paper. 1. Today I want you to imagine that there's a line in front of you. At the beginning of the line is a 0 and the name John in above the 0. At the end is a 10 and the name Anne is written above it. John is a bad listener - he never allows the speaker to finish what he's saying, he interrupts constantly and is always giving advice etc. (Build up image of a "bad listener"). Anne, on the contrary listens well, she really tries to understand what the person is saying and watches them closely while they speak etc. (Build up picture of good listener). Now where do you think you would be on that line? Write down your number. (Teacher gives guidance on how to do this.) Teacher to assess self also.
a. content listening	The difficulties of content listening	2. Ask for five volunteers for next exercise. Send them out of room keeping one back. Tell volunteer that he must listen carefully to the following paragraph. Read out any short paragraph (+ - three sentences). Tell listener that he has to tell it to the next person. Call in No.2, number 1 shares with 2, and then 2 shares with 3 and repeat until 5 has been told paragraph. By this stage it will have undergone some changes and children will be able to see

		a. how difficult it is to listen b. exactly how the listening breaks down
	Can one rate one's own listening skills?	3. Refer back to number rating on paper. Tell children that it is NOT possible to rate yourself as a listener: only someone else can judge whether you listen well because they will feel listened to or not listened to by you. Allow children to move freely - ask two other people in the room where they should be rated. Stress, honesty.
	Barriers to rating of listening skills.	4. Discuss results e.g. whose ratings were constant? If there was a big difference, why? Who rated the person who asked them according to whether they like that person or not.
	Interpretation of test results.	
b. empathetic listening	Barriers to empathetic listening.	Ask children what they remember about listening from last session. GAME 3 1. Seat children in one large circle. 2. Tell children, "I am going to tell you something about me and when I have finished I want each one of you to comment back as if I'd met you in town and said the same thing to you." (Give e.g. It's very cold today.) 3. Make statement (teacher), "I feel so ugly today." Pupils write comment down (give one minute).

iii) Examples of Project and Test Questions

(Suggestions by author)

1) Define cultural evolution. Write an essay to explain how cultural evolution and biological evolution have contributed to the concept of Human Rights as these are expressed by organizations such as the United Nations.

2) Library Project

Choose a group of people with a different culture from your own. They should speak a different language, have a different religion, eat different kinds of food, have different types of houses and also in other ways live rather different life styles.

Find out as much as you can about the people you have chosen and then answer the following questions.

i) List down the things that are much the same in your life and the life of the people you have chosen to study.
ii) Can you explain any differences in terms of evolutionary and population processes such as selection, migration and adaptation?
iii) Explain some of the differences in terms of the cultural evolution of the two groups.

3) Discuss the following ideas in your class and then write an essay of about five pages in length reviewing the points listed.

Topic:

> "In the natural world there are many 'limits' imposed e.g. limits to the distribution of species, limits to the life span, limits to resources and so on. Are there limits to the basic human freedoms of free speech, freedom of religion and so on? Discuss this idea."

Points to Consider:

Potential harm to others
National security
Respect for truth
Threats to peace and to law and order
Public moral values
Accepted social customs - e.g. rules about marriage
Interference with the freedom of others
Keeping a balance between "freedom" and "limits to freedom"

Conclusion:

Come to some conclusions about the biological value of "freedom" for the wellbeing of the human species.

4) Many of our present ideas about human rights and freedoms probably began many thousands of years ago and emerged from a concept called natural law. This concept is that there is a natural order in the universe because all things come from nature. All things have their characteristics and are subject to the "rules of nature" and life reaches its full potential only if the rules of nature are followed. The idea of rights and freedoms, therefore, comes from the idea that anything that limits a person's human qualities is against the laws of nature.

The idea of human dignity, therefore, involves maintaining freedoms and rights and these in turn emerge from a belief in natural laws.

Question

i) List down some of the natural laws which have resulted in the characteristics by which we define a human being.

ii) Write an essay arguing for and against the idea that the concept of human dignity is essentially a biological concept.

Notes and References

Note: Sources of exemplar materials are cited in the text and are not included in this list.

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(8) Selim, M. Saber "The Contribution of Biology Education to Health in Egypt". *Biological Education Newsletter* No 10 March 1984 pp 22-27

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(12) Schaefer, Gerhard *Health Education and Biology Teaching* (Science and Technology Education Document Series No 12). Paris: Unesco 1984 pp 16-19

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(14) Sheehy, G. *Passages: Predictable Crises of Adult Life*. New York: Dutton, 1976

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(17) Spicker, Stuart "Genetics and Ethics: Why Study Human Heredity? *in* Biological Sciences Curriculum Study (BSCS) *Basic Genetics a Human Approach*. Colorado Springs: BSCS, 1983 pp 81-84

Chapter 7

MEETING IMMEDIATE COMMUNITY NEEDS

7.1 Introduction

The types of needs reviewed in Chapter Six are relevant to the concerns of an individual. They are the basic psychological needs or states of deficiency or tension in particular individuals inferred from the observation of their goal directed behaviours (1).

There are other types of need. These are the needs which the community at large believes should be achieved leading to behaviours which ought to occur. That is they are normative rather than individual in orientation, stressing what people should do or accomplish.

Normative needs emerge from the social mores, economic pressures, political climate, ethical codes and value systems of a particular group prevalent at a particular time in its cultural evolution. There are therefore considerable variations from cultural group to cultural group. In spite of this, there is a growing world consensus about issues such as social and economic sustainable development, the need for world peace, effective use of leisure, the right to work, social equity, the need for a stable and secure family life and so on.

The world community tends to perceive these broad needs in two categories. The first is that group of needs which are of urgent immediacy and must be addressed now. The second category refers to more future oriented needs involving ongoing behaviours or planning for future action. For example an immediate need is to increase awareness about the problems of the environment whereas a longer term more future oriented need is to ensure that all citizens become involved in effective environmental management to ensure sustainable economic and social development.

The distinction between "immediate" and "future oriented" normative needs is somewhat arbitrary. There are overlaps in many cases simply because one leads to the other. Nevertheless for convenience this present chapter (Chapter 7) deals mainly with needs with a more immediate orientation and Chapter 8 considers those needs with more obvious ongoing or future oriented implications.

Chapter 7 therefore reviews examples of approaches to biology teaching which could promote positive behaviour in areas of daily living such as environmental awareness, coping with large populations, family life, work related needs, current bioethical issues, effective use of leisure and aspects of equal opportunity.

As in the case of Chapter 6 each area is introduced by a short rationale relating the need to the biology curriculum and examples are provided of relevant content, activities, projects and test items.

7.2 Environmental Awareness

i) Rationale

The environmental education movement is now well established and influential in almost all school systems of the world. In some cases separate courses in environmental studies have been established but the more popular option has been to deal with environment matters as a curriculum thread in most if not all subjects, but especially in science subjects, geography, economics, social studies, technics and fine art. Whichever approach is favoured, however, environmental issues should have a central place in any programme of secondary school biology.

This section deals only with heightening awareness about the environment. More future oriented aspects such as general environmental management, planning for sustainable development and other longer term aspects of environmental studies such as resource management and the search for alternative resources are dealt with in Chapter 8.

As previously mentioned (Chapter 2) the key concepts of environmental education as proposed by the United Nations Environment Programme (UNEP) are as follows (2):

A. Levels of Being: Human, biological and physical levels regulated by universal environmental laws across different time scales. The levels are distinguished by "profound and mysterious" qualities such as life, consciousness and self awareness.

B. Cycles: Transformations (but not creation or destruction) of matter on Earth is powered by the sun. Biogeochemical cycles maintain the purity of materials needed by living organisms. The cycles form a control mechanism maintaining conditions hospitable for life.

C. Complex Systems: Everything is interconnected and form systems of stocks and flows. Stock/Flow patterns are different for renewable and non-renewable resources. Systems are organized into hierarchies so that some interconnections are stronger than others. The complex systems of nature are finely tuned, stable and resilient and diversity generally increases resilience.

D. Population Growth and Carrying Capacity: Populations when they can grow, do so exponentially, to the limit determined by their resource base. The limits imposed by resources needed is the carrying capacity of a population and carrying capacity can be enhanced or degraded by human activity.

E. Ecologically Sustainable Development: Human wealth and economic development depend on the resources of the Earth. These resources will be sufficient only if they are well managed.

F. Socially Sustainable Development: The key to development is the participation, organization, education and empowerment of people. Development must be cultural, reactive and equitable. It should involve careful balance of opposites such as freedom and order; groups and individuals; work and play; settlement and wilderness.

G. Knowledge and Uncertainty: Not everything is known about how the world works and decisions are made in the face of grave uncertainties. It follows that careful assessment, slow experimentation and careful evaluation of results are required with an emphasis on flexible strategies.

H. Sacredness: Nature has intrinsic value and a healthy and beautiful environment is a basic human need. A harmonious relationship between human beings and the environment is not only essential for well being but is also intrinsic, effortless, spontaneous and natural.

It is clear that many of these concepts have a basis in biology. For example

Group A:	Characteristics of life; diversity; individuality; evolution; history of life
Group B:	Resources needed for life; biogeochemical cycles
Group C:	Community ecology including food chains and food webs; availability and management of resources; the importance of biological diversity in increasing resilience of systems
Group D:	Population ecology; distribution; immigration; carrying capacity; efficient uses of resources and population control
Group E:	Stocks of living things and their habitats viewed as stocks of wealth if managed efficiently
Group F:	Cultural evolution and its link with social equity and environmental concern and sensitivity
Group G:	Issue studies in biology; environmental planning; the nature and importance of experimentation and evaluation, the limitations of science in social decision making

Group H: Philosophical aspects of biology including aesthetics, bioethical issues and processes and the concept of human dignity and of humankind's place in nature.

There is therefore a very broad field and only limited aspects are covered by the examples given below. Some aspects such as population studies; environmental and resource management; bioethics and planning and development issues are included in other sections of Chapters 7 and 8.

ii) Examples of Content

Example 7.1: Biological and physical analysis of environment

School System: Papua New Guinea secondary school science
Approach: Teachers' instructions for a study of characteristics of a specific habitat - an area of bushland.
Source: Papua New Guinea Ministry of Education: Science Ecology Teachers Guide Grade 9 Unit 5. Boroko: Department of Education 1981 pp 21-25.

Investigation

THE ENVIRONMENT

INTRODUCTION

Because of the nature of the previous Unit, pupils should be very familiar with most aspects of traditional agriculture. Therefore this topic, which utilizes the traditional garden, will in part use information gathered previously, although it will be used in a different way to produce different results.

ACTIVITY 1. VISIT TO BUSH AREA

Pupils visit a bush area, and fill in the table about things around them. Temperature of the air and soil, plus humidity could be measured to show that physical factors can be measured.

Below is a possible sequence of discussion questions to follow up the excursion.

a) What are the two major parts that make up the environment?
 - Living and Non Living.

b) Do animals and plants share environments?
 - Yes.
 Give some examples you are familiar with.

c) What do plants get from their environment?
 - e.g. minerals, water, shelter perhaps, energy, oxygen, carbon dioxide.

d) How do plants help to create an environment suitable for other plants and animals to share?

- may provide shelter for young plants.
- may provide shade for plants that don't like sunlight.
- provides food and shelter for animals.

e) What do animals get from their environment?
- e.g. food, water, shelter, mates for reproduction.

f) What do animals provide for the rest of the environment?
- e.g. help keep other animals numbers under control by predation.
  help to spread seeds from fruits they have eaten.

g) Do different types of plants and animals each have their own sets of environmental factors that they require to be able to live?
- Yes.

h) Environments are always changing slightly. Sometimes these are regular changes, such as tide movements, or they may be irregular, such as the flooding of a river. A tree falling down in the forest provides a new small environment as it rots, while the space left by the tree lets in more light and allows new plants to grow.

PHYSICAL FACTORS ON LAND

1. Air temperature - some plants transpire too heavily to live in areas and temperature range of high temperature
   - some plants cannot live at cold temperatures
   - animals are adapted to live within a maximum range of temperatures eg between 22-32°C.

2. Soil temperature- affects both plants and animals. cold soil may slow growth of plants or kill animals that live in it.

3. Windspeed
   - very leafy tall trees may not be able to live in strong wind areas
   - windspeed affects transpiration rates- more wind means greater transpiration

4. Prevailing wind - strong wind from one direction for a long time can cause the windward side tree growth to become stunted with less leaves.

5. Sunlight strength - some plants prefer shade, others direct sunlight

6. Hours of sunshine - some plants need a minimum number of sunshine hours to grow properly

7. Amount of precipitation - affects both plants and animals
   - some plants prefer dry or wet soils.

8. Type and strength of precipitation - snow can kill plants
- hail destroys fruits, leaves, young plants.

9. Humidity - affects transpiration rate.

10. Soil Water - very wet soil may rot roots
- affects burrowing animals

11. Soil texture - sandy soil loses its water quickly, is easy to burrow in.
- clay soil remains wet, gets hard if it dries out. Not easy to burrow in

12. Slope - affects drainage. Water may run off too quickly to wet the soil properly.

13. Soil pit - this is a measure of acidity and has a strong effect on plant growth.

NB. There are many more physical factors on land than those mentioned. They also have a much wider range of effects on plants and animals than the examples given. Often the factors are inter-related eg temperature, sunshine, humidity.

What this Investigation should have Taught

1. They consist of Living and Non Living Parts.
2. Everything that lives has an environment.
3. Environments are shared by many animals and plants.
4. Living things obtain everything they need from their environment. They also help create small environments suitable for other living things.
5. Environments are constantly undergoing change.
6. That physical factors can be measured.

STUDENT WORKSHEET – PHYSICAL AND BIOTIC FACTORS

PHYSICAL FACTORS	BUSH AREA	CLEARED AREA	REASONS FOR ANY CHANGES.
SOIL TEMPERATURE			
WET			
DAMP			
DRY			
AIR TEMPERATURE			
SUNLIGHT-STRONG			
STRENGTH-MEDIUM			
-DULL			
WIND -STRONG			
-MODERATE			
-GENTLE			
-NONE			
HUMIDITY %			
HUMUS -LOT			
-SOME			
-NONE			

BIOTIC FACTORS	BUSH AREA			CLEARED AREA			IF THERE HAS BEEN A CHANGE GIVE REASONS.
ANIMALS	MANY	FEW	NONE	MANY	FEW	NONE	
BIRDS							
MAMMALS							
LIZARDS							
SNAKES							
INSECTS							
FROGS							
VEGETATION							
TALL TREES							
BUSHES							
VINES							
GRASSES							
HERBS							
MOSSES							

MARK THE CORRECT COLUMN WITH A TICK.

BEST COPY AVAILABLE

Example 7.2: Comparative study of biomes

School System: Nigeria: Senior secondary school biology
Approach: Curriculum (syllabus) guide for study of a range of biomes including (i) the sea (ii) estuary (iii) freshwater system (iv) marsh (v) forest (vi) grassland and (vii) arid areas. Of these the section on forest studies is given below.
Source: Nigerian Ministry of Education: Biology Curriculum for Senior Secondary Schools. Lagos: Ministry of Education 1985 p 55.

10.2 Forests

Performance Objectives	Content	Activity	Notes
Pupils should be able to: 1. recognize that water is not always as available to organisms in terrestrial habitats as to those in aquatic habitats; 2. recognize that water conservation is an important problem in terrestrial habitats; 3. mention effects of climatic factors on vegetation; 4. identify the characteristics of the forest habitat; 5. recognize trophic levels and distribuiton of animals in a forest; 6. recognize the stratification of plants in a forest; 7. Suggest the food chains.	1. Characteristics of a forest. 2. Strata in the forest. 3. Distribution of plants and animals that inhabit a forest. 4. Adaptative features of the plants and animals.	On a pre-selected site, pupils; (a) observe the pattern of distribution of the bibtic components of the site and their adaptive features; (b) identify the biotic components; (c) collect samples from the site; (d) construct food chains of the biotic components; (e) take readings of temperature, relative humidity, and estimate light intensity.	Reference should be made to the effect of soil on vegetation. The area to be studied shou preferably be previewed a mapped out before pupils are taken there. Warn pupils against dangero animals and twigs.

Example 7.3: Projects on environmental awareness

School System: Austria: Several levels of educational system
Approach: Reports in summary form of secondary school projects on environmental awareness sponsored by the "Environment and School Education" OECS/CERI Project
Source: Pfaffenwimmer, Gunther OECD/CERI Project "Environment and School Education" Austria: National Report. Vienna: Ministry of Education, Culture and Sport March 1988 pp 10-12.

Prof.Mag.Dr. Hans SCHUSTER, Privat-Gymnasium der Herz-Jesu-Missionare Salzburg Liefering (private acad.sec.school), Schönleitenstraße 1, 5020 Salzburg, Tel.: 0662/32270; age of pupils: 15 to 16. Project "Water at Risk" - pollution of the Salzach; The pupils of one form inspected the sewage drains and the water quality of a highly polluted river, cleaned the bed of a brook, talked to representatives of the industry and the authorities and organized an exhibition centering around this issue. They performed role-play on the various interests around the river. They also made a video film on the project, which is currently being used at events for the further training of teachers.

Eva LACKNER, GTS (all-day compulsory secondary school), Wien 16, Roterdstraße 1, 1160 Wien, Tel.: 0222/46 34 37; age of pupils: 10 to 11. Project "Water"; 10 project days were conducted with 80 pupils on the topic "water". At the occasion of an excursion the pupils visited various pertinent places of interest (waterworks, sewage purification plant, etc.) and carried out several exercises; in addition there was "on-site instruction", at which groups of pupils concentrated on particular sub-topics under the supervision of individual teachers; finally groups of pupils concerned themselves with various tasks of their own choice: design of a school pond, design of an exhibition on the topic "water and Industry", a campaign for the protection of water, etc.

Prof.Mag. Gottfried MAIR, BRG Imst (Fed.Ac.Sec.School), Füllsackstraße 13, 6560 Imst, Tel.: 05412/3197; age of pupils: 17 to 18. Project: "Positive and Negative Environmental Phenomena in my Vicinity": In co-operation with experts, local politicians and teachers pupils of two forms conducted several initiatives in order to change certain local environmental aspects: design and implementation of two municipal parks, design of a motorway parking, documentation of the fauna and flora of a mountain gorge and measures to achieve its protection. Also a waste scheme for the municipality of Imst was developed. The work was partly carried out outside of normal instruction, partly within the framework of an optional subject.

Prof.Mag.Dr. Gerd SCHINDLER, BG and BRG (Fed.Ac.Sec.School), Ferdinand Jergitsch-Straße 21, 9010 Klagenfurt, Tes.: 04222/51 17 35; age of pupils: 12 to 13.The project aimed at a critical evaluation of the linguistic means used for the discussion of environmental problems. The pupils' work was divided in an analytic and a constructive phase
In the first phase the pupils compiled press cuttings from Austrian daily newspapers and filed them according to the type of environmental damage and the geographical vicinity to the observer, respectively. Subsequently the texts underwent linguistic analysis (syntax, lexicology, stylistic features, etc.). In the second phase the girls critically examined the contents of the texts by formulating their own positions via statements, letters, letters to the editor, fairy tales and fables. This especially served to train them in various argumentation techniques. In the third phase the pupils laid down their personal ideas for environmental improvement in the form of a book. Not only did the pupils create the texts and the design, but they also provided for the printing and financing of the book.

Prof.Mag.Karl SCHWEITZER, BHAK and BHAS Oberwart (Fed.Intermed. and Higher Com.School), Schulgasse 2-4, 7400 Oberwart, Tel.: 03352/2514; age of pupils: 15 to 16.The project contained mapping and rehabilitation of illegal waste dumps in the district of Oberwart and information of the public in order to prevent the formation of new illegal dumps and to increase public knowledge on that matter. The maps, their evaluation and presentation served as a basis for the rehabilitation, which will be carried out in co-operation with the province of Burgenland, the mayors and the Labour Market Board. The pupils participated in an expert seminar and subsequently delivered about 30 lectures on "waste" in the district of Oberwart. The project served as a model for similar campaigns throughout the Burgenland and Styria. The mapping of waste dumps was complemented and expanded by the registering and removal of wrecked cars together with the Road Administration Authority in the district of Oberwart.

Karl Zimmerhackl, HS Haslach (Comp.Sec.School), Sternwaldstraße 24, 4170 Haslach, Tel.: 071263; age of pupils: 12 to 13. Karl Zimmerhackl, a teacher very much committed to environmental protection, supported by the province and through a funding campaign broadcast by the radio, was able to buy two lots of land (a wetland and a dry meadow) and induced other schools to similar campaigns. As a result of this campaign "butterfly meadows" covering an overall surface of 3000m^2 came into being in the surroundings of 47 Upper Austrian schools. The biotopes, a pond with a small wetland and an orchard, as well as a dry meadow, where hedges were planted, are taken care of by the pupils and are utilized for open-air school work (examination of butterflies, birds, herbs, etc.).

Prof.Dipl.Ing. Werner KVARDA; HBLVA für Gartenbau (Higher Vocational School of Horticulture), Grünbergstraße 24, 1130 Wien, Tel.: 0222/83 35 35; age of pupils: 18 to 22. Project "Complex, Integrated Thinking, Designing and Acting within the Framework of a Village Renewal Schemes"; In the school year 1986/87, the final form of the Horticulture School examined the community of Sooss in order to learn about complex structures and problems in the area of e.g. landscape architecture in individual communities. At the beginning of the project the pupils discussed the tasks, problems and objectives with those responsible (local council) and those concerned (citizens). Subsequently a status report and an analysis were carried out in the village (analysis of the village-scape, biotope mapping, interviews, levelling measurements, etc.). After the evaluation of the data designs and reports were prepared and a portfolio of measures was developed. The target was to publicly present the results of the project in the form of a report, an exhibition and a slide show:

-suggestions for a draft programme concerning landscape architecture
-suggestions concerning waste disposal
-management scheme for an "educational hiking trail" giving information on forestry and viticulture

On Nov. 18, 1987, these suggestions and draft programme were also publicly presented in Krems, at the occasion of the 1st European Village Renewal Congress!

Example 7.4: Pollution studies

School System: USA: State of Louisiana, secondary school biology
Approach: Curriculum (Syllabus) Guide for unit on environmental pollution
Source: State of Louisiana Department of Education Biology I Curriculum Guide Bulletin 1646. Baton Rouge: State of Louisiana Department of Education 1984 revised 1988 p 72.

	OBJECTIVE	CONCEPT		STUDENT ACTIVITIES
207.	The student will identify and explain the various types of natural pollution over the past 1,000 years. these include sources of air pollution, water pollution, and chemical pollution.	Natural pollution	1.	Discuss events speculated to have caused the extinction of dinosaurs and other forms of life.
			2.	Describe the volcanic eruptions of Mount Vesuvius, Krakatoa, and more recently, of Mount St. Helens. See issues of National Geographic or other related articles. Videotapes on Mount St. Helens and Krakatoa are available.
208.	The student will be able to describe various types of man-made pollution over the past thousand years. These include sources of air pollution, water pollution, and chemical pollution.	Man-made pollution	1.	Request guest speakers from the Department of Environmental Quality, Sierra Club, industry.
			2.	Request DEQ publications on air pollution, water pollution, acid rain, hazardous wastes, monitoring systems.
			3.	Have students collect newpaper and magazine articles or conduct research dealing with current pollution problems in Louisiana, the United States, or worldwide.
			4.	Discuss problems associated with thermal inversions and air pollution.

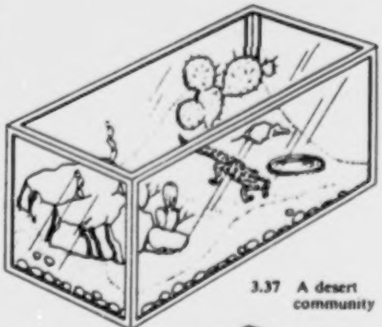
Example 7.5: Construction of terraria illustrating selected habitats

School System: Secondary school biology
Approach: Instructions for practical work on establishing simple terraria
Source: Unesco: New Unesco Source Book for Science Teaching. Paris: Unesco 1973 pp 164-165.

3.37 *A desert community*

If you don't live near a desert, you'll have to get material for your desert community from places near at hand. You can get sand from a beach or garden supply store. Some kinds of desert animals, including horned lizards, can be found in pet shops. The lizards will eat small insects such as ants and mealworms (also available from pet shops).

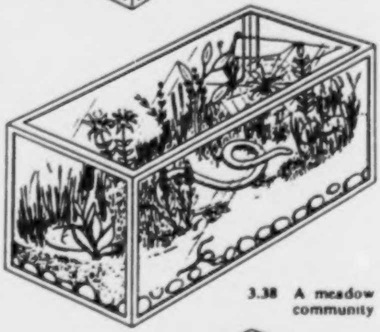
You can buy small cacti from florist shops or general stores. Also get some succulents, which are plants that hold water in their fleshy leaves. Besides the plants, put some rocks in the terrarium, making cliffs or overhangs near the edges (see sketch). Put a small dish of water in one corner. Leave an open area of sand in the centre, especially if you have a horned lizard (you will discover why). The temperature of the desert terrarium should be kept between 20° and 27° C.


3.37 A desert community

3.38 *A meadow community*

The problem here is limiting yourself to a few of the many grasses, weeds, seedling trees, and other plants that grow in meadows. There are also many animals to choose from, including spiders that spin beautiful orb webs. These spiders need lots of room, such as a 50-litre aquarium tank, in which to make their webs.

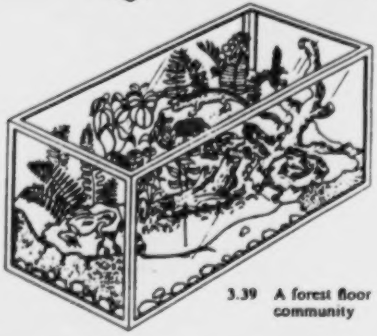
You may find plants with insect eggs or cocoons on them; watch to see what hatches from them. If you want to have one larger animal in the terrarium, try to find a small garter snake. It will eat earthworms and large insects. Be sure to keep the terrarium fairly dry, since snakes often get skin diseases if kept in damp surroundings (see sketch).


3.38 A meadow community

3.39 *A forest floor community*

This is the kind of habitat most often modelled in a terrarium. For plants, obtain small ferns, tree seedlings, wildflowers, and especially evergreen plants such as partridgeberry or wintergreen. Put a few of these plants into the soil and cover the rest of the surface with mosses, attractives stones, and perhaps a small limb (see sketch).

For animals, look for small toads, frogs such as cricket frogs or tree frogs, and red newts (which are small salamanders). These animals and the plants of the forest floor all need moisture, so keep the terrarium well-watered and make a small woodland pool in one corner.


3.39 A forest floor community

Example 7.6: Community involvement in reconstruction of traditional flower garden

School System: Federal Republic of Germany - Bavaria
Approach: Account of a school project to establish a flower garden to grow local flowers common in the area in former times
Source: Volksschule Glonn "Rural Eco-Garden" OECD/CERI Project Environment and School Initiatives. International Project Exhibition: "Cycles" "The Daily Life of the Family M". International Conference in Linz 26-30 September 1988. Vienna: OECD/CERI in Association of Austrian Federal Ministry of Education, Arts and Sports in Cooperation with the Upper Austrian School Board 1988 pp 22-23.

Note: While this project was undertaken in a primary school it could be readily adapted for junior secondary classes.

Volksschule Glonn
Rural Eco-Garden

Our team consists of one teacher and 25 children aged 8 to 10. Our school is a small Primary School in Bavaria, Southern Germany. The capital of Bavaria, Munich, is about 30 km away. Our village, Baiern-Antholing, is very small and lies in an area of intensive-farming land. Work is done with big machines and each square metre of ground is used for food production. Only few places with flowers can be found, and the old type of farmhouse-garden is slowly vanishing.

So we thought it to be very important for the children to set up a "rural eco-garden" in which they have the possibility to acquaint themselves with nature and living organisms. Instead of thinking only in economic terms, they should experience the abundance and beauty of a broad natural variety of plants. Furthermore they should be offered the opportunity to create biotopes for animals, otherwise destined to become extinct.

In this respect our objectives are:

- to experience our native plants and animals not only in text books
- to know what plants had grown in our village in former times
- to get involved in nature protection as soon as possible
- to ask others for assistance, if the work turns out to be too hard for us
- to consult experts
- to try to induce other people to follow our example
- to help children and adults to become more aware of nature.

First of all we had to negotiate with parents, farmers and the local authorities before we succeeded in taking a 2500sq.m.-plot on lease. After that, pupils, teachers, parents, grandparents and representatives of the environmental authorities cooperated in the planning. The open discussion of conflicting opinions about intensive farming and the significance of the conservation or re-building of natural areas and traditional country gardens is to help the children understand conflicting interests between production-oriented attitudes and nature conservation.

The pupils interviewed the older inhabitants and visited the garden of a 300 year old farmhouse. Then they designed their own rural eco-garden with the help of experts.

Using their plans, the students, together with their parents, planted various high-trunk-fruit trees as these used to grow in former times. In addition 200 native shrubs were set up as wind breakers, as breeding-place for birds and habitats for many other animals.

It was quite difficult to build up the village pond, but, since it was intended that the whole community should take part in this project, some parents and farmers assisted us with their machines. The local associations supported our work with their professional knowledge and activities, and the older generation reported on the former appearance of the landscape and on old farming methods.

At this stage the outputs of the project are as follows:

- The pupils have gained considerable knowledge on species and ecological contexts, and they are able to cooperate self-confidently.
- A closer correlation between school, parents and community.
- The farmers show a growing awareness of the necessity of protecting nature and of their own responsibility and of concrete options in this field.

Example 7.7: "It's Your Choice" A simulation game on environmental awareness

School System: United States elementary schools but readily adapted for junior secondary education
Approach: Instructions for a simulation board game based on a well known real estate game
Source: Coble, Charles R. and Brady, Gentry Ann "Fun + Games = Learning" Science and Children Vol 15 No 2 October 1977 pp 15-17.
Note: The game "It's Your Choice" was originally developed by Charles R. Coble and Edward L. Baker of East Carolina University.

Objective: A game to promote awareness concerning some environmentally related decisions facing our society. Players achieve this objective by accumulating the maximum amount of cash in the time allotted.
Players: Two, three or four (five, if a non-playing banker is used).
Time: Unlimited or arbitrary time cut-off or until only one player has accumulated all of the cash.
Level: 4-7.

Rules:

1. Each player receives $500 from the bank before starting the game.
2. Players roll dice in turn and proceed around the board the number of spaces indicated by the dice. Red zones are environmental threats; white zones offer solutions. Other squares indicate safety zones and "Environmental Chance".
3. Each time players land on a red zone they pay the bank $15. Red zones are not for sale.

4. Each time players land on a white zone they have the choice of buying it for $50, if it has not been purchased previously by another player. The money goes to the bank.
5. Each white zone can be improved three times. The owner can, at his turn, purchase improvement cards from the bank for $50 each. Only one improvement card can be purchased per turn.
6. Players landing on white zones owned by other players must pay the owner the appropriate fine each time they land there.
7. The fine value doubles each time a zone is improved:
   Purchase Price $50; fine $10.
   1st Improvement $50; fine $20.
   2nd Improvement $50; fine $40.
   3rd Improvement $50; fine $80.
8. When players land on safety zones they are free from any fines. Safety zones cannot be purchased.
9. Players receive $200 each time they pass GO.
10. Players carry out the commands of the Environmental Chance Cards each time they land on one of those spaces. Chance Cards are returned to the bottom of the deck.

Materials Needed:

1. Game Board, as illustrated.
2. White Zone Cards, one for each zone.
3. Improvement Cards: 12 for first improvement, 12 for second improvement, and 12 for third improvement (use different colour for each stage of improvement).
4. Twenty Environmental Chance Cards with the following messages:

   Pay $50 to the bank for spilling oil into the river.

   Collect $25 from the bank for picking up litter around the school.

   Lose a turn for having the radio on too loud.

   Collect $25 from the bank for each White Zone Property owned.

   Go To Jail - your company failed to follow clean air regulations!

   Pay $100 to the bank for rodent control: the last American eagle was killed.

   Collect $125 from the bank for an Amtrak trip to any place you desire.

   Get Out Of Jail.

   Radiation from an industry in the area: move forward four spaces.

   Got food poisoning from unclean food: lose two turns.

   Treated for hearing damage after a rock concert: pay the bank $100 for medical bills.

   Pay Sanitation Department $35 for picking up trash.

   Received eye damage from sitting too close to the colour television: pay $25 to the bank for medical bills.

   Clothes ruined by smog: collect $75 from the bank.

   Collect $150 from the bank for reducing your use of home energy.

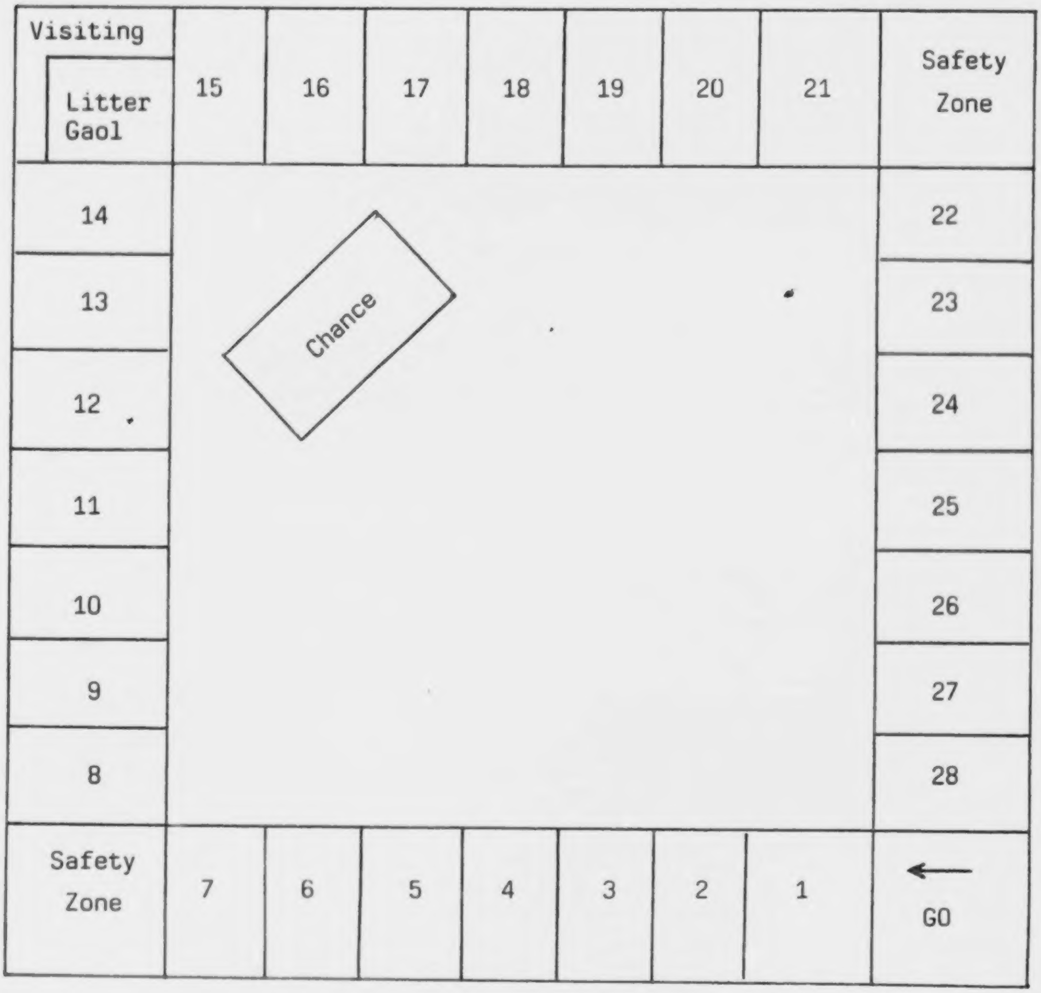
   Car in shop to have the pollution control device repaired: skip one turn.

Your neighbourhood wins a beautification award: collect $50 from the bank.

Advance to GO and collect $200.

Utility bill too high: pay an extra fee of $25 to the bank.

You deserve a break! Advance to the nearest Safety Zone.



Visiting
Litter Gaol
15
16
17
18
19
20
21
Safety Zone
14
22
13
23
Chance
12
24
11
25
10
26
9
27
8
28
Safety Zone
7
6
5
4
3
2
1
GO

Key:

1. Strip mining
2. Mine land recreation
3. Garbage and litter
4. Environmental Chance
5. Recycling centres
6. High energy cost
7. Reduced energy cost
8. Unclean water
9. New sewerage treatment plant
10. Noise pollution
11. Environmental Chance
12. Anti-noise regulation
13. Cancer causing chemicals in foods
14. "Clean" food regulations
15. Air pollution
16. Clean air regulation
17. Crowds
18. Environmental Chance
19. Family planning
20. Urban sprawl urban and rural
21. Land management
22. Toxic fuel and chemicals in water
23. Clean water regulations
24. More endangered species
25. Environmental Chance
26. Natural preserves
27. Traffic jams
28. Mass transportation

Note: Negative and positive squares could be colour coded with a third colour for "environmental chance".

iii) Examples of Project and Test Questions

- Project: Quiz Game to stimulate understanding of wildlife during visit to an African Game Park.
  Source: Meyer, G. Rex and Frank, Sylvia Quiz Yourself About East African Mammals. Nairobi: Salama Publishers, 1976
  Description: Two hundred multiple choice questions are provided classified alphabetically by type of game. Answers are provided together with simple drawings of all game listed. Visitors to a game park are encouraged to work together to answer all 200 questions and find out their rating according to the following scale:

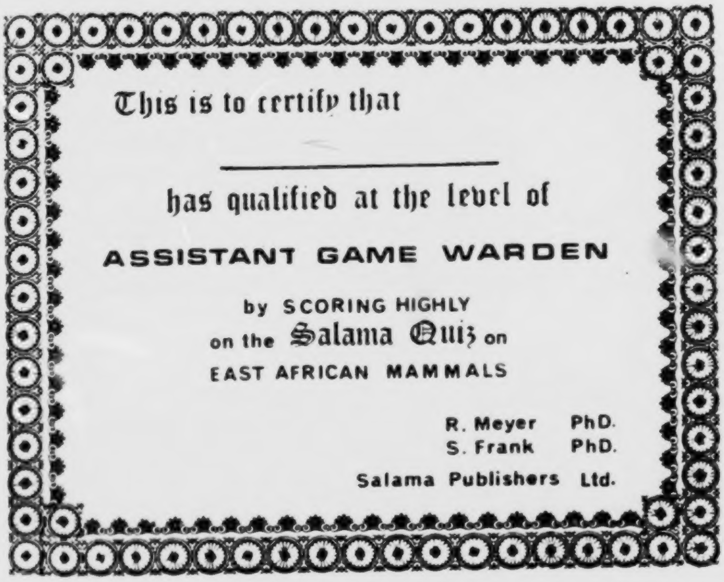
How Do You Rate?

How do you rate as a wildlife expert? Check through the quiz book to make sure that you have attempted all 200 questions. Then add up the number you have answered correctly. Now see how you rate!

Number correct	Rating	What this means about you
Less than 50	TENDERFOOT	You love animals and want to know more about them. You are however only beginning to explore the exciting and wonderful world of African wildlife. We trust you had fun and learnt a great deal from the quiz. YOU QUALIFY FOR OUR TENDERFOOT CERTIFICATE

50-100	PATHFINDER	Your knowledge of the mammals of East Africa is above average. You are keenly interested in natural history and enjoy finding out more and more about the unique and beautiful animals of Africa. Perhaps this little quiz game helped you increase your knowledge. At least we hope so! YOU HAVE EARNED OUR PATHFINDER CERTIFICATE
101-150	ASSISTANT GAME WARDEN	You have a fine knowledge of African wildlife, out-of-the-ordinary and much above average. You obviously want to know more and more. We hope this book has helped you in finding out interesting things that you did not previously know. YOU QUALIFY FOR OUR CERTIFICATE OF ASSISTANT GAME WARDEN CONGRATULATIONS!
151-200	GAME WARDEN	Very few reach this standard. You are something special. You have a sensitive love of animals and a deep knowledge and understanding of East African wildlife. Perhaps you have enjoyed the fun of checking this out through the quiz questions. SPECIAL CONGRATULATIONS TO YOU! YOU HAVE EARNED OUR HIGHEST AWARD - THE SALAMA CERTIFICATE OF GAME WARDEN

Certificate provided in the book eg:



This is to certify that

____

has qualified at the level of

ASSISTANT GAME WARDEN

by SCORING HIGHLY
on the Salama Quiz on
EAST AFRICAN MAMMALS

R. Meyer PhD.
S. Frank PhD.
Salama Publishers Ltd.

Examples of Questions - answers provided.

GIRAFFE

70. Man has 7 bones in his neck. The number of bones in the neck of the Giraffe is -
    - A. 7
    - B. 10
    - C. 25
    - D. 35

(A)

71. The Giraffe is the tallest animal known. He can grow to a height of -
    - A. 3 metres (10 feet)
    - B. 4.5 metres (15 feet)
    - C. 5.4 metres (18 feet)
    - D. 7.5 metres (25 feet)

(C)

72. When Giraffes reach to drink water they usually -
    - A. kneel
    - B. lie down
    - C. spread their front legs apart
    - D. stand upright and bend their flexible neck

(C)

73. The common (Maasai) Giraffe has dense blotchy dark brown markings on its fur. The reticulated Giraffe on the other hand has -
    - A. geometrical brown spots alternating with round areas of white
    - B. round white spots with connecting brown lines
    - C. round brown spots alternating with square areas of white
    - D. geometrical brown areas with connecting white lines

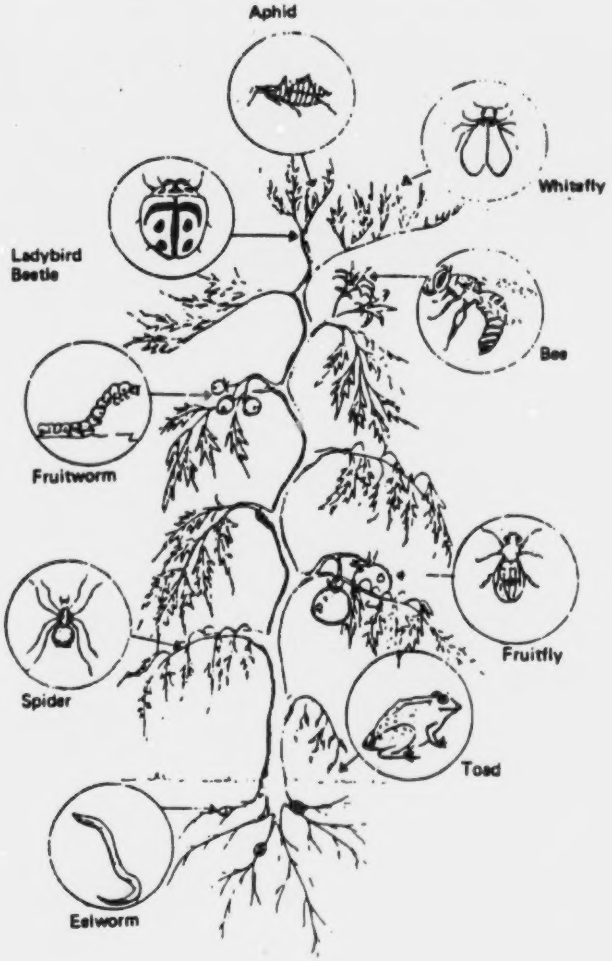
(D)

74. Today Giraffes are found in tropical Africa only. Fossils of Giraffes have been dug up in -
    - A. Australia, South America, Antartica, South Africa
    - B. Greece, Persia, India and China
    - C. Russia, United States, Germany and United Kingdom
    - D. East Africa only

(B)

- Project: Analysis of a community in a garden situation.
  Source: Ministry of Education, Papua New Guinea Science Ecology Item Bank Grade 9 Unit 5. Boroko: Papua New Guinea Department of Education 1984 pp 31-32

Below is a diagram of a tomato plant and several other organisms which might live around or on it in a garden. Study the diagram then answer the questions which follow.


Aphid
Whitefly
Ladybird Beetle
Bee
Fruitworm
Fruitfly
Spider
Toad
Eelworm

FIELD RECORD SHEET

Name of animal	Number of Animals Found	Food of Animal
Green Aphids	35	Sap
Whiteflies	20	Sap
Honey Bees	2	Nectar
Fruitworm	5	Greenfruit
Fruit Flies	10	Ripe fruit
Eelworm	5	Young roots
Ladybird Beetles	3	Green Aphid, Whiteflies, Fruit Flies
Brown Spiders	2	Whiteflies, Fruit Flies
Toad	1	Variety of insects

(a) Write one food chain in this community.

________ → ________ → ________ (1½ mark)

(b) (i) Which animal do you think is the most harmful pest?

____

Give a reason for your answer.

____

________________________________ (1 mark)

(ii) Your tomato garden is infested with white flies. Which of the animals shown in the diagram would you introduce to control them?

________________________________ (½ mark)

(c) Using your understanding of a pyramid of numbers explain why the number of ladybird beetles in this community is so low.

____

____

________________________________ (2 marks)

(d) Name TWO animals which could be competing for food.

________________ and ________________ (1 mark)

. Project: Analysis of local environment. Make a survey of the local environment near your school or home. If you live in a town or city walk around one or two blocks If you live in a rural village drive, cycle or walk about one kilometre roughly to the north, south, east and west (4 kilometres altogether). Take a notebook and pencil with you and make notes about what you see. Try to make observations that will help answer the following questions.

a) What percentages of the land you have seen has been built on?
b) What percentage of the land has been used by people to grow things?
c) What percentage of the land has been set aside for recreation or pleasure?
d) What types of animals did you see? Which ones were present in large numbers, moderate numbers and low numbers?

e) List some things that you feel could be improved in terms of appearance, safety, health, recreational opportunity, transport and any other aspect you consider important.

Source: Suggestion by author.

. Test Questions

1) Questions 91 through 94 are based on the following diagram of a forest. The letters on the left, matching forest layers, are to be used to answer the numbered statements.

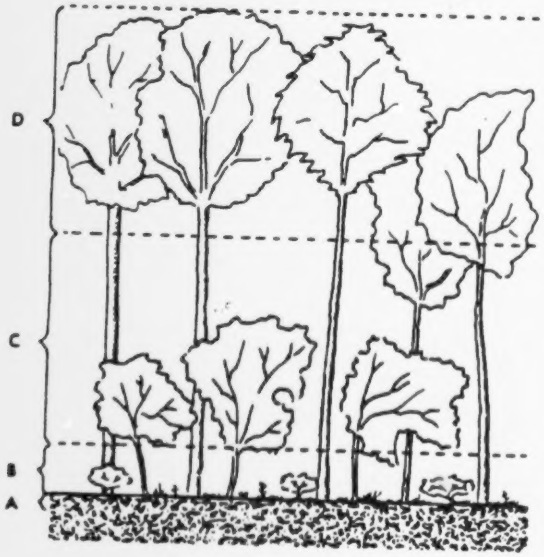
91. Where is most of the photosynthesis occurring? (D)

92. A slight decrease in light would be most critical for the plants in which layer? (B)

93. Where would most annual herbs be found? (B)

94. Where would the humidity be the greatest? (A)

Questions 91 through 94 are based on the following diagram of a forest. The letters on the left, matching forest layers, are to be used to answer the numbered statements



91. D Where is most of the photosynthesis occurring?

92. B A slight decrease in light would be most critical for the plants in which layer?

93. B Where would most annual herbs be found?

94. A Where would the humidity be the greatest?

Source: Mayer, William V. Assessment: A Practical Guide to Improving the Quality and Scope of Assessment Instruments (Science and Technology Education Document Series No 16). Paris: Unesco (undated) p 137.

2) 6. Here is an investigation where a farmer is trying to find out about the condition of his veld and what factors influence (affect) vegetation production. He is interested in having the best possible grazing for his cattle. He made various measurements such as:

i. clipping and weighing vegetation from sample quadrats;
ii. finding out about the weight loss from grass bundles left in soil to decompose;
iii. time taken for 100mls of water to sink into the soil;
iv. determination of % organic matter in the soil;
v. determination of % soil moisture;
vi. amount of sand and clay in soil;
vii. estimate of % basal cover.

He made all these measurements in two places, A and B. These were about 50 m away from each other. His results are presented in the following table:

Sample place	Weight of vegetation from sample square (Biomass)	% loss of weight from grass bundle	% organic matter in soil	% soil moisture	Amount of clay & sand in soil	Time taken for 100 mls water to sink into soil	% basal cover
A	55 gms	6%	8%	10%	more clay than sand	3 mins	12%
B	10 gms	8%	2%	8%	more clay than sand	15 mins	2%

Place a tick against the statement in 6A and the statement in 6B, which you think is most accurate. Refer only to the figures in the table.

6A a. Soil moisture is important in determining (showing) how much vegetation can be produced in the veld ....

b. The proportion of clay to sand in the soil is important in determining (showing) how much vegetation can be produced in the veld ....

c. Veld becomes significantly more productive and valuable to the farmer as the % basal cover increases ....✓...

d. The production of veld vegetation will increase according to the ability of soil to bring about decomposition of organic matter ....

6B a. When water sinks quickly into the soil the production of veld vegetation is likely to be higher than when it sinks in slowly ....✓...

b. When water sinks slowly into the soil the weight of moisture in the soil increases greatly ....

c. When water sinks quickly into the soil it is a general sign that the condition of the veld is not good. ....

d. The time taken for water to sink into the soil depends entirely on what proportion of sand and clay is present ....

Source: Parker, Sylvia *Studies in School Ecology*. Harare: University of Zimbabwe, Science Education Centre 1974 p 98.

3) I. TRUE or FALSE. If the statement is true write TRUE on the blank; if it is false, write FALSE.

_____ 1. Water resources development is one of the primary reasons in preserving our forest resources.

_____ 2. A forest cover is permanent.

_____ 3. The water resources of a community influence the activities of the people.

_____ 4. Sedimentation decreases the storage capacity of streams.

_____ 5. Forest litter cushions the soil from raindrop impact and therefore decreases soil erosion.

_____ 6. The slope of the land is an insignificant feature of a watershed.

_____ 7. Prevention of floods and erosion is an indirect benefit we get from forests.

_____ 8. The slash-and-burn practice of clearing an area reduces our forest resources.

_____ 9. Agroforestry involves both protective and rehabilitative measures because forest trees are grown in combination with crops on marginal and submarginal lands.

_____ 10. Shifting cultivation is a wise land-use practice because it provides a means of livelihood for people.

_____ 11. It may be assumed that pouring a bucket of water on the "spongy" earth increases the groundwater resource by just that amount.

_____ 12. Streamflow is derived solely from rainfall.

_____ 13. Surface runoff begins as soon as the rate of falling rain exceeds the rate of infiltration.

_____ 14. The construction of dams deprives the agricultural land of much fertilizing silt brought in by flood water.

_____ 15. Forest litter decreases the infiltration capacity of streams.

ANSWER KEY

I. 1. T
2. F
3. T
4. T
5. T
6. F
7. T
8. T
9. T
10. F
11. F
12. F
13. T
14. T
15. F

Source: Institute for Science and Mathematics Education Development (ISMED) University of the Philippines: Watersheds (Philippine Environment Series: Water Resources). Manila: ISMED 1988 p 50.

4) Four short answer essay type questions:

a) What ways are there of fighting [agricultural] pests other than by using biocides?

b) What precautions should be taken to ensure that drinking water is not contaminated? List some of the ways in which water may be polluted.

c) How is the body affected by chemical poisons found in polluted air?

d) How does industrial waste pollute the environment?

Source: Kenya Institute of Education SSP Biology Pupils' Book IV Experimental Edition School Science Project (East Africa). Nairobi: Jomo Kenyatta Foundation 1971 p 143.

5) Study this food chain.

cabbage → caterpillar → lizard → small bird → eagle

A farmer sprays his cabbages with DDT to stop the caterpillars eating his cabbages. DDT is a long-lasting insecticide which gets stored in the fatty tissues of the body - it is not excreted.

Which animal will have the highest concentration of DDT in it?

A. caterpillar
B. lizard
C. small bird
D. eagle

6) Look at the following food chain from the Manus area.

phytoplankton → zooplankton → smallfish → tuna → shark

If Starkist comes and catches large amounts of tuna in the Manus area, what will happen to the other living things in the food chain?

A. The sharks and zooplankton will decrease in number and the phytoplankton and small fish will increase in number.

B. Only the sharks will decrease in number, and the phytoplankton, zooplankton and small fish will increase in number.

C. The sharks and zooplankton will increase in number and the phytoplankton and small fish will decrease in number.

D. Only the phytoplankton will decrease in number and the sharks, zooplankton and small fish will increase in number.

Sources of Questions 5 and 6. Ministry of Education, Papua New Guinea: Science Ecology Item Bank Grade 9 Unit 5. Boroko: Department of Education Papua New Guinea 1984 pp 12-13.

7.3 Population Issues

i) Rationale

In the more conventional types of secondary school biology programmes population studies are usually treated as part of ecology (3). Issues such as the capacity of an organism to increase, fluctuations in natural populations, the influence of environmental variables such as weather, resources, members of the same and other species and environmental hazards are treated formally. Reference is usually made to case studies of non-human species relevant to the biology of the country concerned. In Australia, for example, school courses generally include studies of pests such as rabbits and prickly pear and indigenous species such as magpies, kangaroos and grasshoppers (4). Topics given particular emphasis include predator-prey relationships, the issue of carrying capacity and overcrowding and population distribution, including migration, zonation and succession.

A socially oriented school biology programme, on the other hand, focuses more on the social and economic consequences of human demography, and especially on problems associated with the human population explosion of the last century. The main example becomes a case study of humankind rather than magpies, kangaroos or rabbits (5). Social consequences are reviewed. Only those aspects of the more formal approach to population ecology which are necessary to explain the characteristics of the human population are included.

ii) Examples of Content

Example 7.8: Problem of overpopulation

School System: Malaysia - secondary schools
Approach: Background reading for students in Form V Biology
Source: Malaysian Ministry of Education. Modern Biology for Malaysian Schools Form V. Kuala Lumpur: Longman for the Ministry of Education, Malaysia 1974 pp 34-35

9.3C Overpopulation (Background Reading)

Over-population is one of the gravest problems which mankind has to face in the immediate future. This seems inevitable due to several factors including ignorance, prejudice and a blank refusal to face the facts.

Over-population conveys different meanings to different people. In this context, over-population is regarded as the state in which a country has an inadequate food supply to maintain a healthy population. Although good health and adequate food are not the only requirements of a satisfactory existence, they are the crucial factors in helping to keep the ever-increasing human population alive and fit.

One overriding factor leading to over-population is the reproductive capacity of human beings. Human beings have such a capacity for reproduction that a population of any large community living in favourable environmental conditions may easily double and redouble itself every twenty-five years or so. It follows, therefore, that the food supply must also be doubled and redoubled at the same rate. A progressive increase at this rate obviously cannot be maintained for long and thus it will result that there ceases to be a balance between population and food supply.

The world population did not pass the 100 million mark until after the time of the Old Kingdom of Egypt and did not exceed 500 million until about 1650. It reached 1,000,000,000 in the mid-nineteenth century and exceeded 2,000,000,000 in 1930. Thus the first doubling of population was reached in about 200 years (that is, from 1650 to 1850), and the next doubling in about 100 years (from 1850 to 1950) and it is predicted that it will have doubled itself again by about 1980.

The magnitude of the growth of human population is best appreciated by looking at the world situation in the mid-1960's. The world population was then 3,220 millions, about 270,000 babies were born and 143,000 people died every day. This gave a daily surplus of 128,000 births over deaths, or 47 million a year on an average, an annual increase of 1.7%. The rate of increase is not uniform throughout the world. For example, in the South Asia region, an increase of 2.4% was experienced at that time.

Population may expand basically under three sets of conditions:

1. Birth rate remains the same but mortality rate goes down.
2. Birth rate increases and death rate remains constant.
3. Birth rate increases and mortality rate decreases.

Under modern technological advancement, the latter seems to be the primary cause of population expansion. With modern medicine, people seem to live longer and die at a very much later age.

Inadequacy of food does not seem to limit the size of either population or of families. In fact the reverse is true. In crowded countries, like India for example, near famine conditions do not control the numbers and frequently it is the underfed who have the largest families. Nature, regarded as a "mother", shows little interest in the comfort and well being of her children; her one concern is the survival of the species, and the mechanisms by which this is promoted is by lavish production of offspring when conditions are such that survival and health seem least likely.

Even modern highly productive agriculture will only be able to feed the ever increasing numbers of population for a limited time.

So we are now confronted with two major problems in trying to overcome over-population:

1. What is the population level (size) which must be set to ensure the chances of survival for all?

2. What measures of control must be instituted which can be acceptable by the people?

The technologically advanced countries such as Japan, have controlled the number of births by using various methods of birth control. Malaysia also has launched a birth control programme on an extensive scale.

Although the problem seems to be a simple one it is not easy to solve. The success of any technique intended to control the population is closely allied with two factors. These involve the process of educating the people on the subject and their ability and willingness to appreciate the problems involved.

If over-population continues to be unchecked a number of undesirable situations will occur. One of the most obvious effects is malnutrition - inadequate supply of the necessary constituents of a healthy diet. The other effect which might arise is the state of barbarism. It has been said that this kind of behaviour has been fostered in recent times by some countries which have adopted policies of aggression.

It will be evident that, if a community desires to secure and maintain reasonably good standards of health and longevity, apart from control of infectious diseases, there should be an increase in food production and a regulation of birth rate in such a way as to preserve a satisfactory balance between population and food supply.

Example 7.9: Food supply and population growth

School System: Australia: secondary school biology
Approach: Classical experiment with yeast to illustrate limits to growth of a population
Source: Cohen, David; Hill, Jennifer; McDonnell, Kevin, and Meyer, G. Rex Biology Practicals for Senior Students. Melbourne: Heinemann Educational Australia 1989 pp 98-99.

CF14 *The effect of food supplies on population growth*

The food supply of a population is one of the major resources which determines its potential for growth.

In this investigation, you will set up a micro-community of yeast cells and, by varying the food supply, gain some understanding of how the growth of a population depends on this resource. By containing the population in a limited area, you may also detect the effect of waste build-up (pollution!) on a population.

INQUIRY

To study how a population of yeast cells grows under varying conditions of food supply.

MATERIALS

yeast granules
table sugar (crystals)
100 mL measuring cylinder
eye dropper or Pasteur pipette
light microscope
slides and cover slips
six flat-bottomed specimen tubes
cotton wool
gummed labels and grease pencil

PROCESS OBJECTIVES

By the end of this activity you should be able to:

1 use a microscope to observe a yeast population sample

2 record the growth of a yeast population in table and graph form

3 relate population growth to availability of food.

PROCEDURE

A Measure 50 mL of tap water and pour it into a flat bottomed tube.

B Add two small granules or one large granule of yeast and shake vigorously for 5 minutes to completely disperse the cells.

C Before the cells can settle, use an eye dropper to obtain a drop from the middle of the suspension. Transfer this drop to a microscope slide, cover with a slip and examine under magnification × 400.

D Count the number of yeast cells visible in the field. Repeat for four other samples and obtain the average number per field of view. If the number per field is greater than 10, add an appropriate amount of water to the suspension until this approximate dilution is obtained.

E Re-shake the suspension and quickly divide it into five equal portions, placing each portion into a 2 cm test tube. Label the tubes 1–5.

F Add grains of sugar to each tube according to the table below. Stopper each tube with cotton wool and shake until the sugar is dissolved.

Tube	1	2	3	4	5
Grains	0	5	10	20	40

G Set the tubes aside at room temperature. After one and a half hours, shake each sample well and take five counts from each to determine the average number of yeast cells per field.

H Repeat the process every 1½ hours (or as close to this as possible). Try to take at least four such readings. Record all values as they are obtained.

Result table (showing suitable layout)

Tube	Average no. cells per field					
	time zero	time:	time:	time:	time:	time:
1						
2						
3						
4						
5						

I On the same axes, plot, for each tube, numbers of cells per field against time in hours. Use different colours for the lines representing the different populations.

J Draw conclusions from, and provide discussion about, your results.

QUESTIONS

1 Which tube had the most cells after six hours?

2 Which curve showed the steepest gradient? Are your answers to these questions related? Why?

3 Is there any indication that there is a limit to how much a yeast population can grow in a confined space?

FURTHER INQUIRY

1 Allow the experiment to run for 24 hours—plot curves as before and explain any changes in the shape of the curves not seen in the earlier experiment.

2 Determine the number of cells produced in every 1½ hour period for 24 hours and draw the graph of number added per 1½ hours versus age of population (hours). Comment on the shape of this curve.

Example 7.10: Rate of population change

School System: Australia: senior secondary school biology

Approach: A quantitative exercise based on the mathematical concept of an innate capacity of a species to increase (r_m)

Source: Cohen, David; Hill, Jennifer; McDonnell, Kevin, and Meyer, G. Rex Biology Practicals for Senior Students. Melbourne: Heinemann Educational Australia 1989 pp 99-100.

CF15 Rate of population change

One ecological concept developed for studying the rate of population change, is the innate capacity for increase of a species (r_m). For example, if r_m of a population is stated to be 3 per cent per annum, the population is increasing by three individuals for every hundred *each year*.

The value of r_m, of course, depends mainly on birth rates and death rates, which in turn are controlled by the components of the population's environment. In this activity you are going to establish an imaginary situation and calculate how the populations of *two different organisms living in the one area* might change, as the environment changes.

It is useful for ecologists to study such hypothetical situations in order to develop models to aid understanding of population change. These models can then be tested by making studies in the field.

INQUIRY

To find what sorts of changes might take place in nature, when two populations living in the same area experience randomly varying climate.

PROCESS OBJECTIVES

By the end of this activity you should be able to:

1 perform an experiment simulating changes in two populations under a varying climate

2 assess the validity of the model used as a guide to what happens in nature.

MATERIALS

(for each pair of students)

one six-sided die

graph paper

Some preliminary assumptions about our two imaginary species (alpha and beta)

Let us suppose that:

1 The period of reproduction for both species is one week.

2 When the population size of each species changes an equal ratio of males : females is maintained.

3 r_m for species α is: (i) +50 per cent when maximum temperature for reproductive period (one week) on average is above 37°C. (ii) -30 per cent when maximum temperature for reproductive period on average is below 37°C.

4 r_m for species β is: (i) -20 per cent when maximum temperature for the reproductive period on average is above 37°C. (ii) +10 per cent when maximum temperature for the reproductive period on average is below 37°C.

PROCEDURE

A 1 Using this model, calculate the changes in population size of α and β for an initial population of ten of each species, over a period of ten weeks.
   - a when the maximum temperature on average exceeds 37°C;
   - b when the maximum temperature on average is less than 37°C.

2 On the same axes, plot numbers versus time for each species over the period studied under the two different conditions.

B 1 Let us now consider a situation where the average weekly temperature fluctuates above and below 37°C such that four weeks in every six have average temperatures below 37°C.

2 Mark a six-sided die in such a way that four of the sides represent temperatures below 37°C e.g. you might decide to let die sides 1, 2, 4, and 6 represent these weeks. Sides 2 and 5 will therefore represent weeks above 37°C. You can now use the die to predict, on a random basis, variation in weekly temperatures in our imaginary environment.

3 Predict changes in population of α and β over a fifteen week period starting with ten individuals in each population. Roll the die 15 consecutive times to determine the average temperature which prevailed in each week. The results of the die rolling will lead to the r_m value operating for that week and so allow calculation of the new population size.

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4 Plot a new graph to show the changes in population sizes of α and β under the varying conditions determined by the die rolling.

QUESTIONS

1 Which of the two species might survive in:

- a the Sahara desert
- b the Arctic Circle?

2 Under the conditions presumed in the second part of your investigation (the die rolling part), do either of the populations become extinct in that area? Would they if the investigation were continued for another 15 weeks?

3 In what way do such imaginary situations resemble the natural situation? In what ways do they differ?

FURTHER INQUIRY

Does the second part of your investigation (using the die rolling) always give the same results? Repeat it and find out or compare your results with those of other groups.

Example 7.11: Problems of overpopulation in a specific country

School System: Hong Kong secondary school biology
Approach: Extract from an approved textbook reviewing the problems of overpopulation in Hong Kong
Source: Hong Kong Ministry of Education Approved Text F4/5. Hong Kong: Department of Education. Undated p 263 (From photocopy supplied by Ministry)

The pressures of overpopulation

World population in 1965 was estimated to be 3,300,000,000, that is 3.3 billion. By 1976 it had risen to 4 billion, an increase of 20 per cent. At the present rate of growth, world population in the year 2000 is estimated to be close to 7 billion. The staggering magnitude of the increase can be appreciated by plotting a graph of world population throughout history (Fig. 6.58).

While world population is increasing, the size of the earth is of course staying the same, natural resources are being depleted and pollution increases daily.

Clearly, if mankind is to succeed at all in the battle to conserve the environment and preserve a reasonable standard of health, housing and food supply, the growth of world population must be slowed down and ultimately reversed.

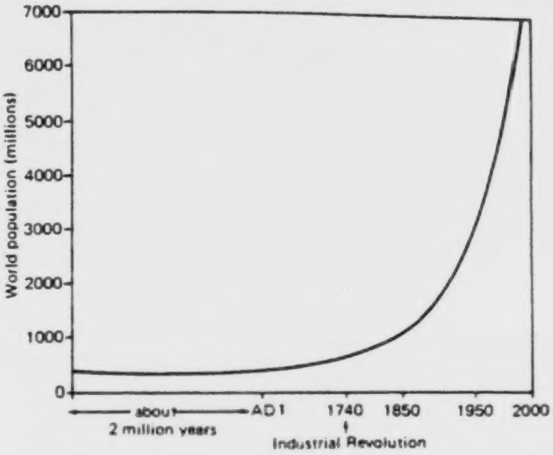


Fig. 6.58 Graph showing world population throughout history

Does Hong Kong have a population problem?

The population of Hong Kong in 1945 was just over half a million. By 1979 through natural population increase and immigration the figure had risen to 4.9 million.

Today certain parts of Kowloon have some of the highest population densities in the world.

At the same time there has been a dramatic increase in the pollution of our streams and rivers, of the coastline and urban areas. Overcrowding and noise are approaching such proportions as to endanger the health of the more susceptible individuals. If this level of population growth is maintained, the results in 10 to 20 years will be clearly disastrous.

How can Hong Kong's population be controlled?

Because population increase involves people and their basic human rights, it is an extremely difficult problem to deal with. Deciding how many children to have and when to have them should be a basic human right of every couple. All that governments can do is to advise that couples should restricted themselves to two children.

Example 7.12: Human population trends

School System: -
Approach: *Background reading on historical changes in human population and its social consequences*
Source: *Spellerberg, Ian F. and Pritchard, Alan J. Ecology, Ecosystem Management and Biology Teaching (Science and Technology Education Document Series No 10). Paris: Unesco 1984 pp 19-20.*

Populations

The human population has increased dramatically during the 20th century. Estimates of human population size and changes in population before the 17th century are based on circumstantial evidence and Deevy (1960) has drawn attention to three interesting periods of rapid growth (Fig. 16). About a million years ago, the first was linked with tool-making; ten thousand years ago, a second increase can be attributed to development of agriculture; a third increase commenced around the time of the industrial revolution (about 250 years ago).

Population growth during the last few centuries has been expontential. The main contributing factors include improved agricultural practices and advances in medical sciences, which have promoted better levels of survival of different human age-classes. The dramatic increase in the world's population has inevitably resulted in an increased demand on the world's food and other resources. Efforts to reduce population growth rate in some countries have included various methods of 'birth control'. Throughout history, migrations, coupled with changes in population growth rates, have led to considerable variations in population density (Table 4). Whereas population growth rate in the 18th and 19th centuries was faster in parts of Europe than elsewhere, from about 1850 to 1950 the growth rates in North America and Latin

America exceeded that for Europe. As a consequence of these patterns, a detailed description of human population growth needs to be quantified with information on population density and dispersion.

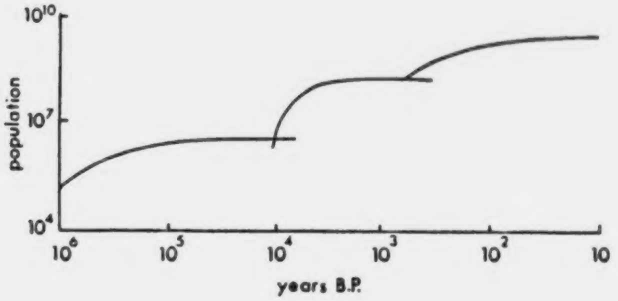


Figure 16. Human population growth expressed in the form of a logarithmic population curve. After Deevy, E.S. (1960), Scientific American, 203, 195-204.

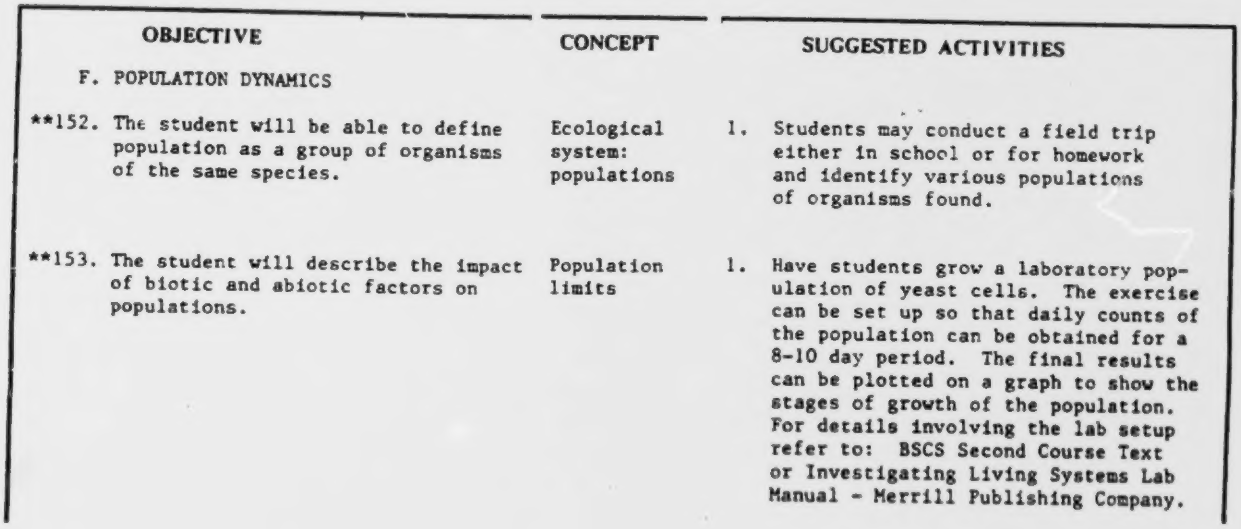
Table 4. Land area and population density in the world and major areas, 1960 and 1975. From Ehrlich, P.R. *et al*. (1970), Ecoscience, W.H. Freeman & Co.

Area	Land area (1000 km^2)	Inhabitants per km^2	
		1960	1975
World total (excludes Antarctica)	135,779[a]	22.1	29.4
More developed regions	60,907	16.0	18.6
Less developed regions	74,872	27.0	39.5
Europe	4,936	86.1	96.0
USSR	22,402	9.6	11.4
U.S. and Canada	21,515	9.2	11.0
Oceania	8,509	1.9	2.5
South Asia	15,775	54.9	80.4
East Asia	11.756	67.0	85.5
Africa	30.320	9.0	13.2
Latin America	20.568	10.5	15.8

Urbanization is an important aspect of human population density and dispersion. The process of urbanization has occurred for thousands of years but only more recently has the rate increased dramatically. It is calculated that about 40 percent of the world's population is now concentrated in urban areas and that this could reach about 50 percent by the year 2000. Each year, in developed countries, at least 3,000 sq.km. of prime agricultural land is lost to urbanization. For example, between 1960 and 1970, Japan lost 7.3 percent of agricultural land to urbanization and European countries lost between 1.5 and 4.3 percent. The effect of urbanization is not easily described in general terms because of different effects in different parts of the world. One common result, however, has been the change in incidence and levels of epidemics. Although medicine has made considerable advances, there is still a lot to be done to control epidemic diseases. Crowding increases the rate at which a disease can be transmitted and appearance of new strains of virus also presents additional problems.

Example 7.13: Syllabus topics on population dynamics

School System:	*USA: State of Louisiana secondary school biology*
Approach:	*Curriculum (syllabus) statement on population studies within a programme of secondary school biology*
Source:	*State of Louisiana Department of Education Biology II Curriculum Guide Bulletin 1820. Baton Rouge: State of Louisiana Department of Education 1987 pp 51-56.*



OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
F. POPULATION DYNAMICS		
**152. The student will be able to define population as a group of organisms of the same species.	Ecological system: populations	1. Students may conduct a field trip either in school or for homework and identify various populations of organisms found.
**153. The student will describe the impact of biotic and abiotic factors on populations.	Population limits	1. Have students grow a laboratory population of yeast cells. The exercise can be set up so that daily counts of the population can be obtained for a 8-10 day period. The final results can be plotted on a graph to show the stages of growth of the population. For details involving the lab setup refer to: BSCS Second Course Text or Investigating Living Systems Lab Manual - Merrill Publishing Company.

		2. Students set up quadrat studies to determine population densities and types of populations found in a given area. This may include field collecting plant and animal specimens to be studied at a later date in the lab. 3. Soil samples may be collected during the quadrant studies and students set up a Berlese apparatus to extract soil nematodes. 4. Have students collect water samples from various sources. These samples may be tested for dissolved oxygen. (Preparations of reagents and procedures to follow may be found in BSCS Green Version Text--Teacher Ed. 1982 Ed. Houghton Mifflin or Investigations into Living Systems Lab Manual - Merrill Publishing Company). 5. Students measure dissolved oxygen content of two water samples at 10° and 60°C. A determination can be made as to the effects of temperature on dissolved oxygen in water.
*154. The student will describe the concept of carrying capacity.	Population	1. Ask students to predict what their community would be like if their community population doubled or tripled.
**155. The student will describe stages of growth of a population.	Population growth	2. Discuss issues such as housing, food, and lifestyles. 3. Follow up with simulation. 4. Reference: Global Science, 1985, "Activity on Space Trip." 5. Contact NASA regarding space travel. 6. Examine demographic differences between countries such as Denmark, Finland, and Norway. Compare to the United States, Mexico, and Ethiopia.
156. The student will demonstrate an understanding of the early ideas of population growth.	Over-population	1. Assign students material to read about Malthus' Theory. 2. Discuss Malthus' predictions and why they have not come to pass. 3. Discuss why eventually his predictions could come to pass.

157. The student will be able to list several principles pertaining to the organization of population levels. These would include: a. Density--population size in relation to some unit of space b. Natality--inherent reproductive ability of a population c. Mortality--death of individual of a population d. Age distribution--range of groups within the population e. Fecundity--capability of reproducing offspring (females)	Population group properties	1. Study population structures of different organisms. a. ants, termites, bees b. roaches c. birds (starlings, California Condor) d. grizzly bears e. humans 2. Study the demographic structures of western Europe, Egypt, India, Japan, Malaysia, Canada, and the United States. Draw bar charts to show distributions. 3. Obtain population information about shifts in population: age shifts, ethnic shifts, and nationality shift. Discuss how these alter populations.
158. The student will be able to draw and interpret an idealized population growth curve, a logarithm curve, exponential growth, and "plateau effect."	Population density	1. Use a calculator to demonstrate the concept of exponential growth with the analogy of the increase of money in an interest-bearing savings account. 2. Discuss the "Tragedy of the Commons" and how it relates to the global picture.
159. The student will be able to describe geometric population growth and contrast it with arithmetic growth.	Growth patterns of a population	1. Draw a graph showing examples. Use data to graph accurately examples to be used: - growth of a bean plant - growth of an insect population of locusts - growth of a population of hawks 2. Conduct a "modeling exponential growth" laboratory. Use graph paper to demonstrate the concept of exponential growth.
160. The student will be able to explain how to estimate a population growth by using: a. extrapolation b. prediction	Estimating population growth	1. Using the predicting methods, estimate a population growth or change if global nuclear war took place--rat population, roach population, human population.
161. The student will be able to demonstrate that the carrying capacity is determined by the availability of materials and conditions necessary for maintaining a particular kind of organism and that the earth's carrying capacity is limited for all species, including man.	Carrying capacity	1. Estimate the carrying capacity of the city or town in which the students live. Estimate how many students could live in an area the size of their class room. Discuss waste disposal, food, water and other resources.

162. The student will recognize various types of feeding strategies and their effects on populations, e.g., specialized feeder, opportunistic, etc.	Feeding strategies	1. Compare feeding strategies with evolutionary patterns.
163. The student will describe how mortality, fecundity (number of reproducing females) and other demographic factors affect population growth.	Demographic factors	1. Develop charts that show how mortality, fecundity, and other demographic factors have affected population growth.
G. Human Ecology		
164. The student will be able to describe human cultural evolution and its impact on human populations. This should include the development of agriculture.	Population growth	1. Discuss controversies surrounding predicted trends. Assign students readings about various industrial periods that may have affected the present population, and point out what specific factors may have directly altered population growth.
**165. The student will discuss biological factors affecting population such as: a. nutrition b. disease c. famine d. death rate e. birth rate	Population growth	1. Discuss biological factors and how they affect a population and the individual.
**166. The student will be able to recognize why the world's human population increases despite a simultaneous decrease in the birth rate.	Total fertility rate	1. Show students how a decrease in the birth rate affects only one of the factors affecting population growth. Use a matrix to show various factors.
167. The student will be able to recognize the effect increasing population has on the social structure of a civilization.	Effect of population growth on social structure	1. Have students make a comparative demographic study of countries which have a high population density, moderate population density, and low population density (China, the United States, and Australia).
168. The student will be able to recognize the cultural factors affecting population levels.	Cultural factors and population	1. Have students discuss issues that might reduce population growth. Have students examine population growth patterns of Western Europe, North America, Latin America, Africa, and Asia to determine differences that might affect their growth.

169. The student will be able to discuss the effect of urbanization on population levels.	Urbanization	1. Examine how urbanization affects population levels, then predict trends in population growth.
170. The student will be able to recognize that all organisms have the capability of reproducing beyond the availability of food resources.	Population and food supply	1. Have students conduct the Drosophila melanogaster experiment that simulates population growth under specific conditions.
*171. The student will identify and describe renewable and nonrenewable resources and give examples of each.	Renewable and nonrenewable resources	1. Have students list examples of renewable and nonrenewable resources. 2. Predict changes in resources over the next 2,000 years. 3. Consult the global 2,000 report producer under President Carter's administration and compare and contrast President Reagan's administration study on the environment.
172. The student will identify energy sources available to humans, their role in society, and their levels of efficiency.	Energy	1. Examine types of energy used throughout the world. Examine levels of efficiency by modern and third world nations.

iii) Examples of Project and Test Questions

- Project. Analysis of graphs of human population trends.

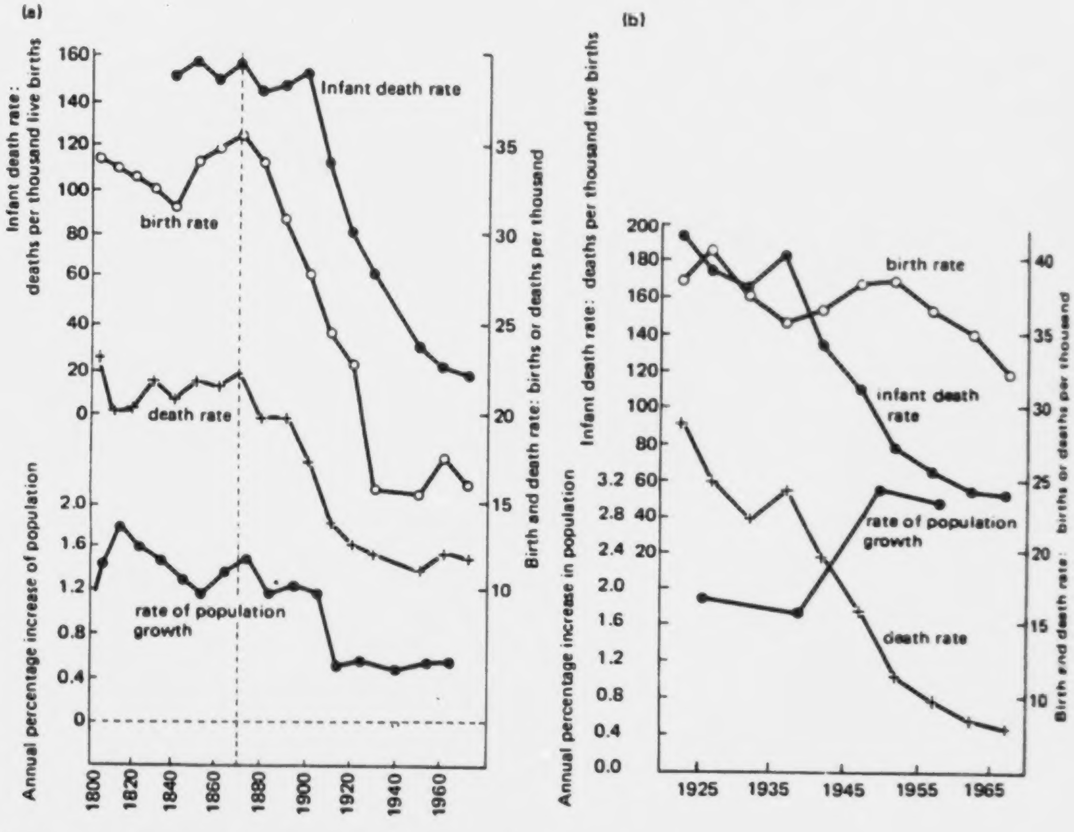


fig 14.37 Birth rate, infant mortality, death rate and rate of population growth
(a) England and Wales 1800–1970 (b) Sri Lanka 1922–1967

Investigation

To examine and analyse graphs of population statistics

Procedure

Examine fig 14.37 and answer the following questions.

Questions

1 In fig 14.37 (a), death rate and infant death rate began to fall in 1870. What social factors do you think contributed towards this decline?

2 What year did this decline begin in Sri Lanka (graph (b))?

3 Why was it delayed so long compared with the United Kingdom?

4 What was the most important factor influencing the fall in rate of population growth in graph (a) after 1870?

5 Why has the rate of population growth significantly increased in graph (b)?

Source: Soper, R., Tyrell Smith, S. and King, W.S. Caribbean Biology for CXC An Integrated Approach Third Edition London: Macmillan 1985 p 286.

. Project. Data and questions for class discussion on human population trends.

Population

Tables

A Doubling time

date	**estimated world population**	**time required for population to double**
8000 BC	5 million	1 500 years
1650 AD	500 million	200 years
1850 AD	1 000 million (1 billion)	80 years
1930 AD	2 000 million (2 billion)	45 years
1975 AD	4 000 million (4 billion)	35 years

B Population estimates for the world 1920–2000, in millions, rounded

	Year								
Area	1920	1930	1940	1950	1960	1970	1980	1990	2000
World	1940	2070	2300	2520	3000	3600	4330	5200	6130
East Asia	550	590	635	690	800	910	1040	1170	1290
South Asia	470	530	610	700	860	1110	1420	1780	2170
Europe	325	355	380	390	425	455	480	505	525
USSR	155	175	195	180	215	245	280	315	350
Africa	140	165	190	220	275	345	450	590	770
North America	115	135	145	165	200	225	260	305	355
Latin America	90	110	130	160	210	285	380	500	640
Oceania	8.5	10	11	13	16	19	22	27	32

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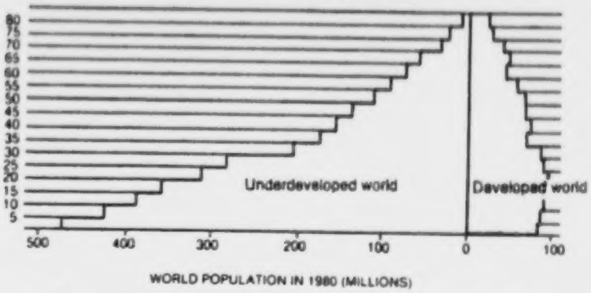
C Age distribution in the world population



Study questions — Population

See also: DIET

1 Some parts of the world are much more heavily populated than others. Try to explain these differences in terms of both resources and the control of disease.

2 At 8000 BC it took a further 1 500 years for the world population to double, yet at 1975 it would take only a further thirty-five years to double. Explain this difference.

3 It has been estimated that by the year 2000 the less well-developed countries of the world will have much larger populations than the richer countries, and yet the poorer countries have fewer resources and inadequate medical facilities. Can you explain this apparent contradiction?

4 Brazil, Zambia and Kuwait are likely to double their populations in less than thirty years yet in Denmark and Britain it may take more than 100 years for this to happen. What is the explanation for this?

5 If the human population keeps growing at its present rate, what is the likely future of the human species? What could be done to control the growth?

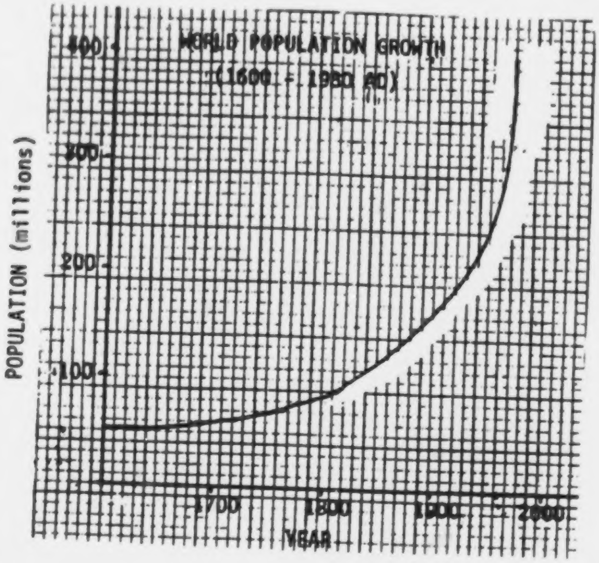
Source: Hawes, James; Macinnis, Peter; Meyer, G. Rex, and Stanbury, Peter Biology Data and Resource Book. Amersham Buckinghamshire: Hulton Educational 1985 p 123

. Test Questions

Source: The following questions 1 to 11 are from Ministry of Education Papua New Guinea: Science Ecology Item Bank Grade 9 Unit 5. Boroko: Department of Education Papua New Guinea 1984 pp 2-5.

Questions 1-3 refer to the following information

1. The world population over the last 400 years has increased as shown below in the graph.



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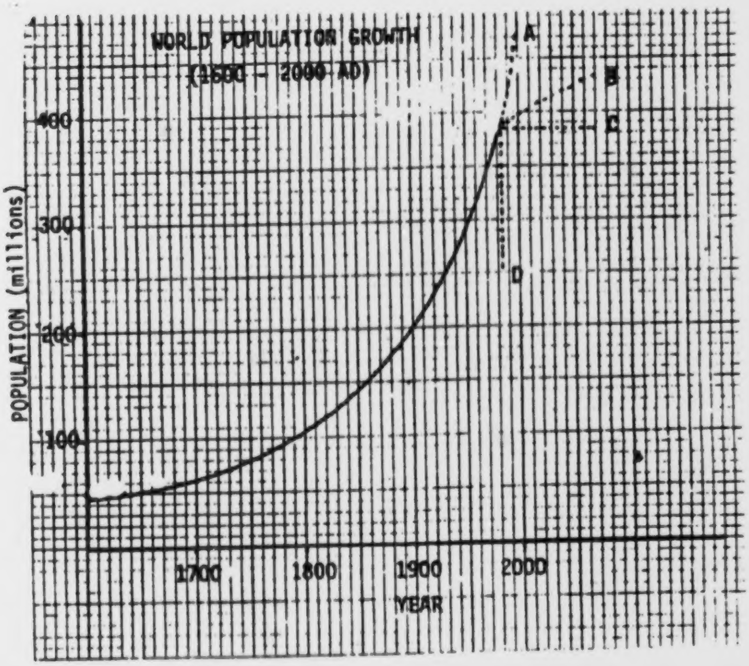
2. The population in the year 1850 was about
   - A. 1,000
   - B. 500,000,000
   - C. 1,000,000
   - D. 1,000,000,000

3. The population in the year 1970 was
   - A. slightly more than in 1900.
   - B. about twice as much as in 1900.
   - C. about 4 times as much as in 1900.
   - D. impossible to tell as the graph is incomplete.

4. The graph shows that the population
   - A. has increased very rapidly over the last 100 years.
   - B. has increased at the same rate for the last 400 years.
   - C. has remained the same for the last 400 years.
   - D. increased rapidly but has stopped increasing since 1970.

5. The world's population is increasing due to
   - A. high birth rates only.
   - B. high death rates only.
   - C. improving standards of living.
   - D. high birth rates and low death rates.

6.

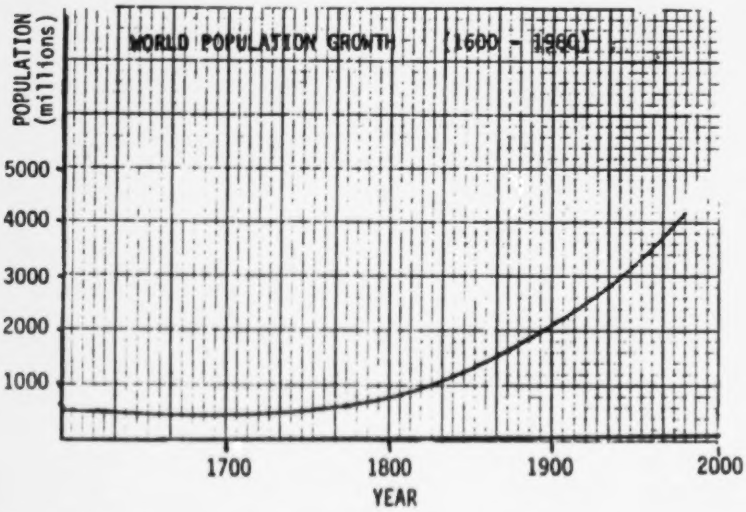


The graph shows how the human population of the earth has increased with time until 1980 A.D.

Which dotted lines show best how world population is likely to change after 1980?

6. Which of the following best explains why the world is facing a population crisis?
   - A. There is a low birth rate and a high death rate.
   - B. There is a low birth rate and a low death rate.
   - C. There is a high birth rate and a high death rate.
   - D. There is a high birth rate and a low death rate.

7. The graph shows the world population growth (in millions) over the past 400 years.



In which years did the population increase the most?
   - A. between 1600-1700
   - B. between 1700-1800
   - C. between 1800-1900
   - D. between 1900-2000

8. Which of the following countries would consume the largest amount of natural resources?
   - A. a small undeveloped country
   - B. a small developing country
   - C. a large developing country
   - D. a large developed country

9. What is meant by the statement that the Earth is a finite system?
   - A. It has a limited supply of natural resources.
   - B. It has an unlimited supply of natural resources.
   - C. It has a plentiful supply of natural resources.
   - D. It has few natural resources.

10. It is often said that the Earth is facing a 'population crisis'.
    This means
   - A. an increasing population and decreasing use of natural resources.
   - B. an increasing population and increasing use of natural resources.

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C. a decreasing population and increasing use of natural resources.
D. a decreasing population and decreasing use of natural resources.

11. Raising the living standard of a population means
A. not using natural resources.
B. using less natural resources.
C. using more natural resources.
D. careless use of natural resources.

7.4 Family Life

i) Rationale

This area has only recently been seen as a concern for secondary school biology. In the past, and at best, courses were limited to biological aspects of human reproduction, sometimes with an extension to family planning and sometimes including an account of sexually transmitted diseases and their prevention.

More recently this central core of concern for the purely reproductive aspects of human behaviour has extended to comprehensive areas of family life including topics such as the following (S).

Individuality in the family (who am I?)
Family roles and relationships
Effective communication in the family group
Safety and security issues - love, support and esteem in the family group
Body parts and their functions - with special reference to reproduction
Sexually transmitted diseases
Health care, physical and mental care
Adolescent/teenage problems
Peer pressure - how to cope
Drug abuse
Physiological/Psychological changes - how to cope
Generation gap
Population - overpopulation
Implications for personal and community development
Family planning and population control
Provision of resources for the family - marketing, budgeting, consumerism
Career planning - education and training.

Many of these topics are basically biological in nature while others involve more socially applied aspects. Much of what can be treated in this area can be related to physiology, personal hygiene, nutrition, personal development, behavioural studies and population issues.

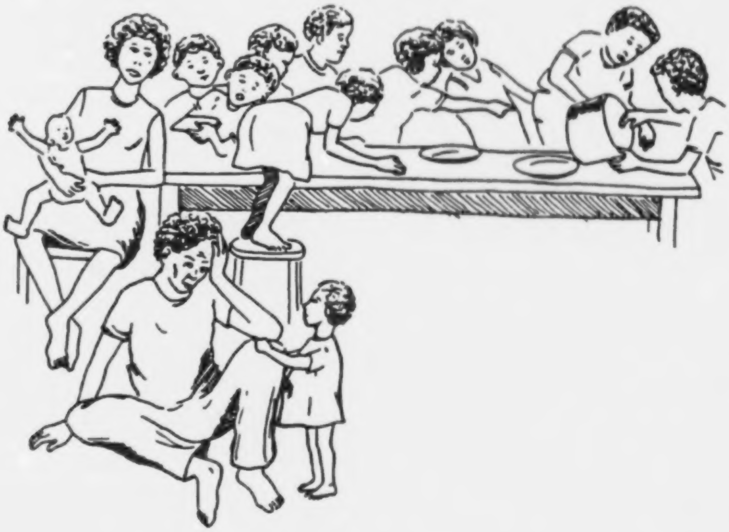
Family life studies can of course also be taught from an interdisciplinary point of view. Many topics from this area can be introduced into subjects such as social studies, mathematics, geography, history, economics, language arts, technics and so on. Nevertheless biology provides a strong foundation and a clear framework for a programme centering on this important area of general education.

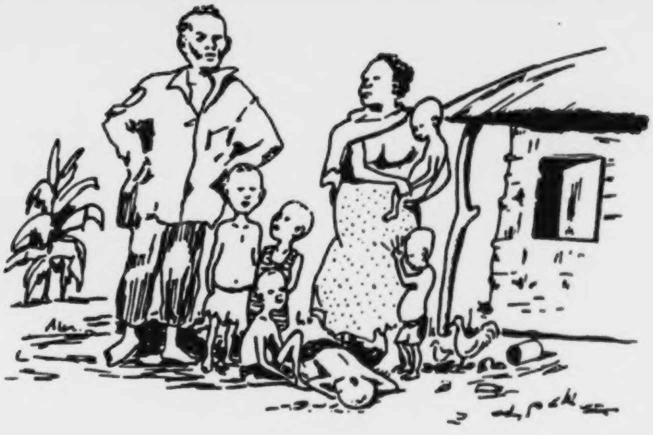
ii) Examples of Content

Example 7.14: Questions and answers on family planning

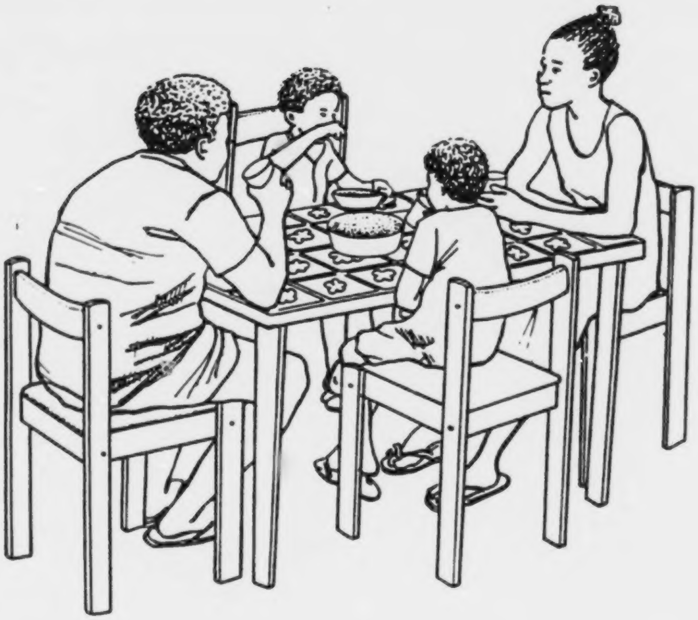
School System: Papua New Guinea secondary school science
Approach: Posters followed by a series of most frequently asked questions
Source: Ministry of Education Papua New Guinea Science Growth and Reproduction Teachers Guide Grade 8 Unit 5. Boroko: Department of Education 1986 pp 170-174.

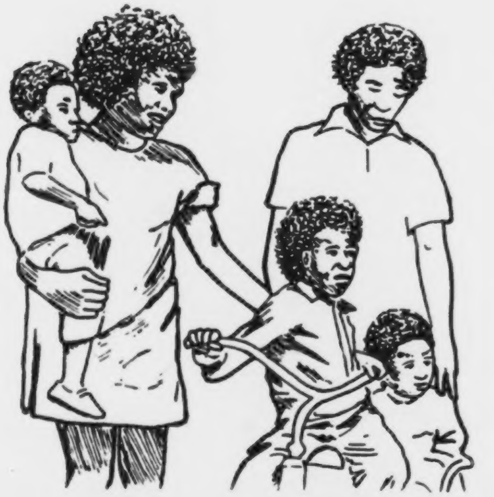
UNPLANNED FAMILIES





PLANNED FAMILIES





QUESTIONS OFTEN ASKED ABOUT FAMILY PLANNING

THE PILL

Q. Do many women use the pill?
A. Yes. Many, many women all over the world use the pill.
Q. What do I do if my next period does not occur after I complete a cycle of pills?
A. Simply begin the next cycle of pills as the doctor or nurse midwife advises. If you miss two periods, it does not necessarily mean that you are pregnant, but you should see your doctor to make sure.
Q. What if I decide to have another child?
A. Finish the cycle of pills you are taking and then stop.
Q. Will the pill affect my sexual drive?
A. Usually it does not. Most women do not notice any difference. A few may notice an increase, and a few may notice a decrease in sexual drive.
Q. Can I take the pill if I am taking any other medicine?
A. Yes. The pill will not have any effect on the other medicine, and the other medicine will not affect the pill.
Q. What will happen if my child accidentally swallows my pills?
A. They should not hurt him, but it is wise to keep birth control pills, as well as other medicine, out of the reach of children.
Q. Will the pills harm my baby if I discover that I have been taking them while I was pregnant?
A. No, but stop taking the pill as soon as you think that you are pregnant. Use another method, such as the condom or foam, until you have been checked by the doctor.
Q. Can I take the pill if I am breast feeding?
A. Usually you can. If your flow of milk should decrease, use a different method of family planning until your child is weaned.
Q. How long can I continue to take the pill?
A. Some women have taken the pill for several years with no harmful effects.
Q. Will the pill delay menopause?
A. No.

NON-CLINIC METHODS

Q. Can everyone use the rhythm method successfully if they do it carefully?
A. The rhythm method can be used most successfully by women who have very regular menstrual cycles and who are very careful about keeping track of days. For women with irregular periods, the rhythm method is very unreliable.
Q. Does the condom protect against sexually transmitted diseases?
A. Yes, but it does not give 100% protection. It is still possible to get a disease when using a condom, if the sex partner is infected.

THE IUD

Q. Can I have an IUD inserted if I have never had a baby?
A. Yes you can. But, insertion is easier after you have had a baby.
Q. Does the IUD cause infection?
A. Not if it is properly inserted and your examination showed that there was no infection in the vagina when it was put in.
Q. If I expel my IUD, can I have another one inserted?
A. Yes, another type of IUD can be inserted, or the doctor may recommend a different method.

Q. Can I still become pregnant after I have the IUD removed?

A. Yes. After the IUD is removed, you will be just as able to become pregnant as you were before the IUD was inserted.

Q. Can the IUD get lost in my body?

A. Usually the IUD remains in the uterus. You will be taught in the clinic how to know that the IUD is in place. Occasionally it is expelled from the body through the vagina. In very rare occasions, an IUD may be inserted improperly, and it will go through the wall of the uterus. To avoid any undue worry, you should return to the clinic as instructed.

Q. Will my change of life come sooner by using IUD?

A. No.

Q. How does the IUD work?

A. Scientists think that when the IUD is inserted, it prevents an egg from resting in the uterus so that a baby cannot form.

Q. Does the IUD affect my menstrual periods?

A. After the IUD has been inserted, you may have a heavier menstrual flow for the first few periods. You may also have a little bleeding between periods. If the bleeding is great enough to alarm you, you should return to the clinic.

Q. Can an IUD be inserted any time?

A. An IUD can be inserted any time.

Q. Will the IUD begin working as soon as it is inserted?

A. Yes.

STERILIZATION

Q. Can I have a normal sex life after I have had a vasectomy?

A. A vasectomy will not interfere with your sex life. You can still enjoy intercourse. The white fluid will still come out, but it will not contain the seeds that can cause pregnancy.

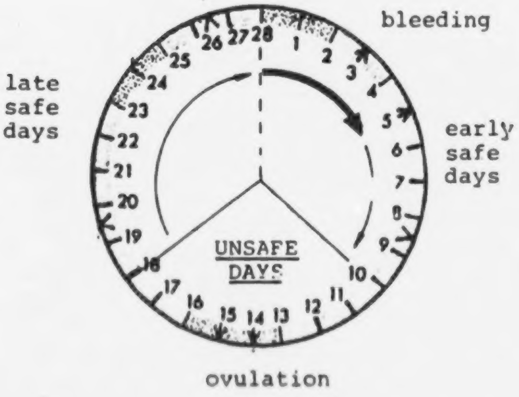
Q. Will a vasectomy be painful ?

A. There may be a little change in colour in the area of the operation and a little discomfort. In a day or two, there should be no problem.

Q. Can a woman be sterilized at any time?

A. Women cannot be sterilized while they are pregnant. Sterilization may be done at any other time. A good time for this operation is immediately after child-birth, while the woman is still in the hospital.

THE MENSTRUAL CYCLE, SHOWING SAFE AND UNSAFE DAYS



Example 7.15: Social aspects of adolescence

School System: Jamaican secondary schools
Approach: Text and discussion questions
Source: Ministry of Education Jamaica Family Life Education Project Source Book for Teachers. Kingston: Ministry of Education 1986 pp 45-48.

THE SOCIAL ASPECT OF ADOLESCENCE

A typical adult of today might complain

> *Our youth of today love luxury,*
> *they have bad manners, contempt*
> *for authority and disrespect for*
> *older people. They no longer rise*
> *when adults enter a room, they*
> *contradict their parents, chatter*
> *before company, gobble their food,*
> *tyrannize their leaders.*

Yet this statement was made by Socrates two thousand years ago.

Of all the stages in a human life cycle, adolescence is the period of most striking change. It is during this time that individuals make the transition from childhood to adult life. The success with which individuals cope with this period of their lives will to a great extent determine the type of adults they will become.

The status and role of the child and the adult in our society are clear cut, but the adolescents have no clearly defined status. Their position is ambiguous – There are times when they may be treated as adults, or as children as is convenient.

Unlike the primitive societies where some form of initiation ceremony at puberty marks the beginning of adult life, the transition to adulthood in our society is a gradual process. With puberty occuring earlier the interval between sexual maturity and adult status is becoming longer.

Conflicts of Values

During childhood we adopt the values of our parents. As we grow older we are exposed to a variety of other influences which make us question traditional values. Sometimes adolescents become aware of a discrepancy between the way they are taught to behave and the way society behaves, and so they begin to question the values passed on through their parents. It is at this stage that adolescents must find out for themselves what their own values are and decide whether to accept or reject the values of their parents and society. Many adolescents make the transition smoothly from childhood to adult life; for others it is a period of insecurity and emotional upheaval. During this time there is a gradual loosening of the bonds with parents. The function of parents of adolescents is to help them to grow up: Parents who allow their adolescents a reasonable degree of independence and decision making, produce more self reliant, well adjusted adults than those who exercise strict control. A rigid attitude by parents creates many problems so that their adolescents eventually rebel, defy parental authority or run away.

The Generation Gap

This is a phenomenon caused by a difference in outlook and lack of communication between parent and adolescent.

It is generally common where parents are entrenched in their attitudes and refuse to accept changes in society. Adolescents find it difficult to accept the values of older people when values are changing so rapidly. Their protest manifests itself in unconventional dress and hair styles, rejection of traditional attitudes, revolt against the establishment, dropping out of school or experimenting with drugs.

Young people like to make their own decisions; they claim the right to choose their own friends, clothes, books, and forms of amusement. However, they still look to parents for advice and can be conscientious, trustworthy, and generous with their time if given the opportunity.

As adolescents move into adulthood, they settle down. Many of those individuals who wanted to change society in adolescent revolt are the same ones who embrace the ideals they once sought to break down.

Problems Facing Young People

1. **Sexual Urges**: The intense sexual urges that accompany puberty are not easily handled. This is not helped by the postponement of marriage for several years beyond the age of sexual maturity. The younger generation today are subjected to pressures to the extent unknown by their parents. They are exposed to a barrage of sexual stimuli and TV and other media, to publicity given by the media to an apparently violent and permissive society.

2. **Youth Culture**: The past two decades have seen the emergence of a distinct youth culture. This is particularly noticed in affluent consumer societies and is gradually catching on in our own society. It is generally accepted that this phenomenon has been artificially created by commercial interests who want to share the increasing spending money of young people. There are shops and stores which cater especially to young people in items like clothes, videos and transistor radios. This exaggerates the generation gap in order to create a media myth devoted to youth. The teenager regarded as a peculiar individual cut off from both childhood and adult life, creates the ultimate peer group – a kind of club to which only the young belong.

   One feature of youth culture is that the patterns of behaviour, attitudes and ideas which are accepted and pursued are radically different from the accepted culture of the society, particularly that of the older generation. This reinforces the generation gap.

3. **Peer Group Pressure**: Although adolescents appear to be suspended between childhood and adulthood, they place great importance on being accepted by their peer group in which they find the approval and acceptance which they feel is lacking at home. But there are times too, when the values of the group are often in conflict with the values of the homes from which they come. This situation sometimes baffles teenagers leaving them confused and causing them to be emotionally and psychologically upset.

   The group however sympathises with his problems and lends support in his rebellion against the establishment. It also serves to smooth the transition between dependence on parental standards and setting up his own. The peer group often times confers the status which his in-between situation denies him.

4. **Examinations**: Adolescents are expected to perform in examinations that are highly competitive and for which many are unprepared. Invariably some of them are compelled to take subjects which to their way of thinking will not fit them for a career. Part of the cultural acquisition demands that long years be spent in schools during which time the young acquire all aspects of the culture that is anticipated will fit them for life. This is not always the case as not every necessary aspect can be anticipated. The result is that much of what is taught is never required, and according to Phillips, "the net result is that schooling become divorced from life and reality." Such a situation sets the stage for boredom which in turn invites rebellion. In addition, the many years between learning and application lessens the will to learn. This leads to inevitable stress and strain and inability to cope with examinations. Guidance and counselling services offered by Principal and staff could help adolescents work toward a career supported by the appropriate 'mix' of subjects. In addition, further support in the form of proper study habits and an effective delivery system, coupled with teachings and discussions on personal development could prove of inestimable value. With this kind of orientation and preparation adolescents could be relieved of much of the stress and strain and be more prepared to operate amidst present competition.

5. **Dissatisfaction with home situation**: Teenagers often become aware of certain home situations with which they are dissatisfied. Some of these might include problems with step parents, with siblings, inadequate economic support, and the double standard practised by those around in terms of values.

6. **Pregnancy and Fatherhood**: This becomes a major problem for the girl especially in that:

   - she is set back in her pursuit of a career for at least one year; and then when she gets back on track she thinks of what might have been accomplished.
   - she may face pressure to marry someone she may not desire as a husband
   - she has added responsibility of caring for the baby
   - she has little knowledge of proper parenting.

   The male might be equally inadequate for the role of parenting both psychologically and economically, and might be forced to leave school and find employment to support the mother and baby.

   A survey conducted in Jamaica some few years ago in adolescent Fertility, showed that a high correlation existed between teenage pregnancy and the girl's self concept. Girls with high self concept showed fewer cases of pregnancy than girls with low self concept. For information on the predisposing causes of pregnancy among student teenagers as seen by principals, read *The Status of Family Life Education in Public Schools* –page 14.

7. **Drugs**: Many adolescents are using drugs not for medical reasons but because they want to experience the effects which the drug can produce such as the feeling of euphoria and well being. Adolescents need to be reminded always of the importance of developing a safety consciousness, and of the harmful effects of drug abuse to the body and the personality.

Many of the adolescent problems are due to lack of knowledge of what is happening to them. And even though the parents had passed through this phase the level of communication to their adolescent children appears inadequate. As a consequence they become confused and insecure with a feeling of inadequacy which finds expression in deviant behaviour.

The Schools' Challenge

Schools have the opportunity to help adolescent students understand the transition from childhood into young adulthood and to support them through their periods of anxiety, doubt and joy. In the Family Life Education programme there are topics on puberty, human sexuality, and personal development and population education. These suitably handled should create a mood, an understanding, a new concept of self, in fact, a way of life. The goal, as in all fields of good education is to assist the student to develop an ethic of responsible action, of individual and social responsibility, and of knowing beforehand the consequences of action and inaction.

These concepts and decision-making skills will be introduced from the lower grades but should find full expression in the upper grades comprising adolescent boys and girls.

Teacher–Directed Activities:

1. Read the opening quotation on page 45 and deal with each charge separately e.g. love and luxury, bad manners, contempt for authority.
2. Are the charges justified?
3. Student experience is invited to refute or support the charges.
4. What are some of the conflicts that adolescents have with parents?
5. Should the adolescents, the parents or both take the blame?
6. What could be done by youth and parents to minimize or prevent conflicts?

7. What part do qualities like patience, communication and willingness to help, play in family relationships?

8. Is there any conflict between you and your school? If so, to what do they relate?

   home work, choice of subjects, the teacher, your classmate,
   peer group, (gang) examinations, other?

   Write two or three paragraphs expressing your feelings of pleasure or discontent and how you propose to resolve the conflict and, OR

9. Role Play to resolve a conflict.

Example 7.16: Family roles in maintaining an aspect of home hygiene - the disposal of waste

School System: Philippines secondary schools
Approach: Illustrated reading material for pupils
Source: University of the Philippines Science Education Center Goodbye Waste. Manila: UPSEC 1983 pp 4-7.

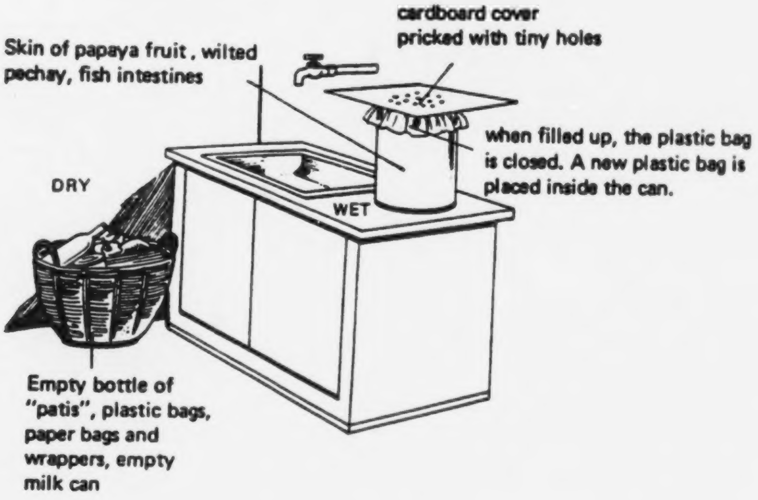
A Visit to the Bayani Home

The Bayani family has a modest home in barangay Malamig.

The area around their home is clean. No garbage heap attracts flies and other insects. No garbage floats in the nearby stream. How does the family get rid of waste?

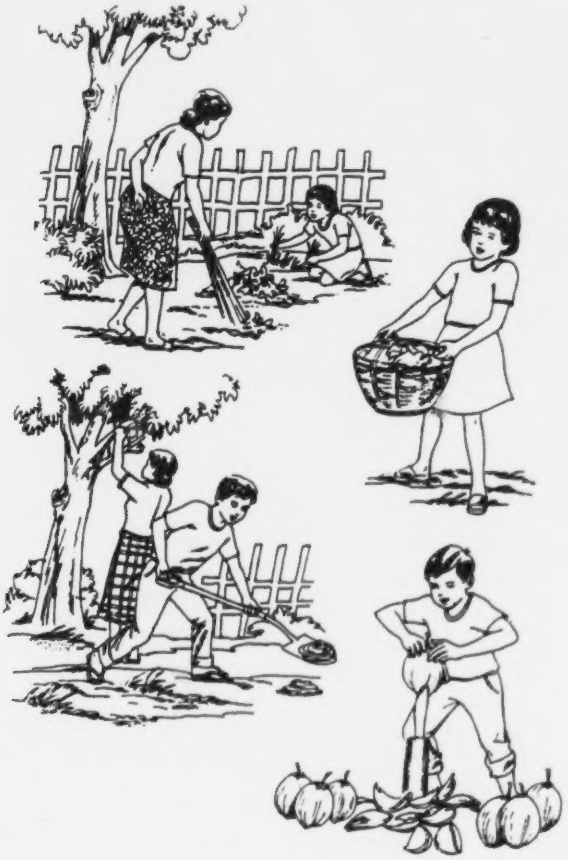
First, the family separates wet waste from dry waste.

In the kitchen, there are two containers. One container holds a plastic bag for wet waste materials. The other container is for dry waste materials.


cardboard cover pricked with tiny holes
Skin of papaya fruit, wilted pechay, fish intestines
when filled up, the plastic bag is closed. A new plastic bag is placed inside the can.
DRY
WET
Empty bottle of "patis", plastic bags, paper bags and wrappers, empty milk can

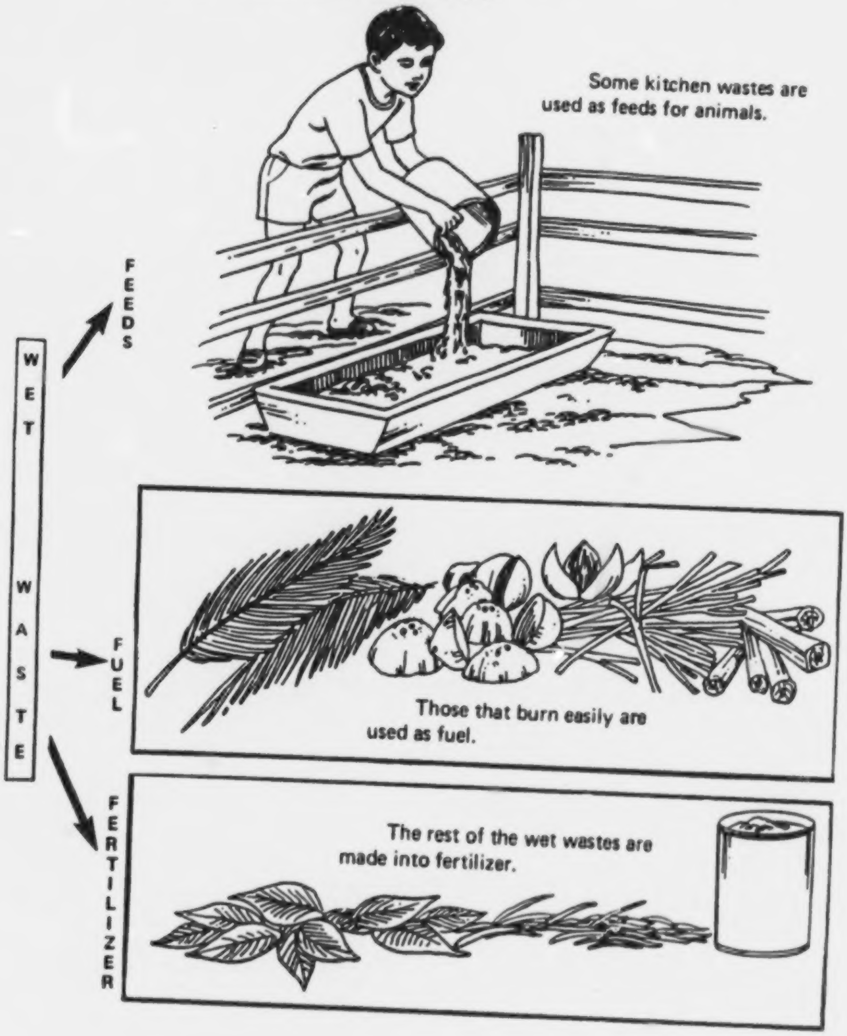
Notice that wet waste comes from food. Wet waste comes from parts of plants and animals.

In the yard, the Bayani family also separates the waste into wet and dry. Look at the pictures below. They show some activities of the family.



1. Name the kinds of waste shown in the picture.
2. Separate these into wet and dry waste.

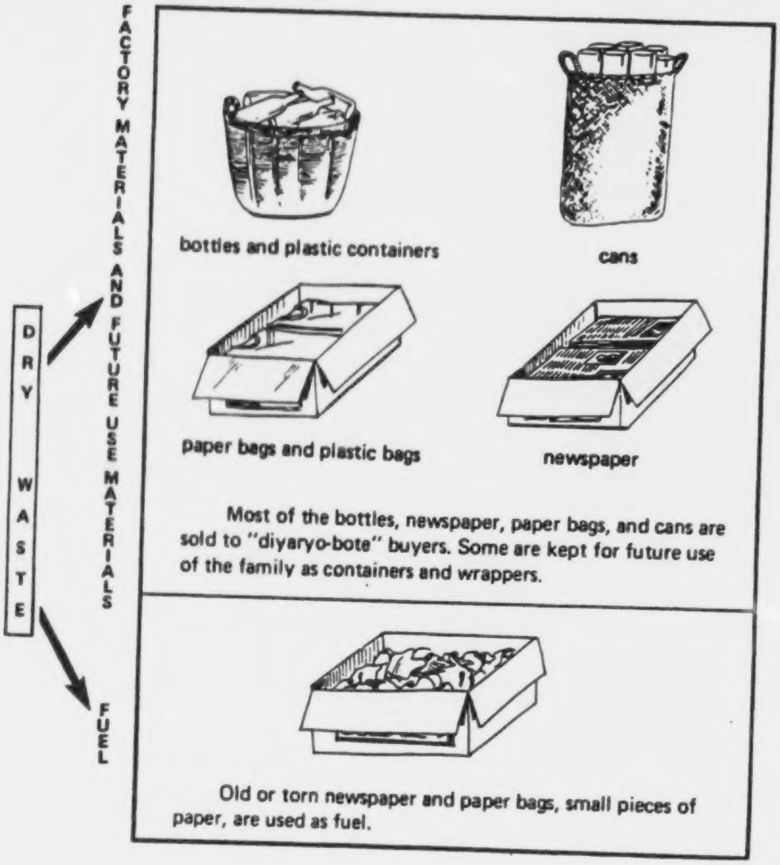
The Bayani family separates the wet and dry wastes further. The family separates the wastes into the 5 F's.



Some kitchen wastes are used as feeds for animals.

Those that burn easily are used as fuel.

The rest of the wet wastes are made into fertilizer.


DRY WASTE
FACTORY MATERIALS AND FUTURE USE MATERIALS
bottles and plastic containers
cans
paper bags and plastic bags
newspaper
FUEL

Most of the bottles, newspaper, paper bags, and cans are sold to "diyaryo-bote" buyers. Some are kept for future use of the family as containers and wrappers.

Old or torn newspaper and paper bags, small pieces of paper, are used as fuel.

Example 7.17: The family food budget

School System: Secondary schools throughout the English speaking Caribbean

Approach: Teachers notes on effective marketing and consumerism. Target: teacher educators

Source: Caribbean Food and Nutrition Institute Food and Nutrition Education A Guide for College Tutors in the English-Speaking Caribbean. Kingston: Caribbean Food and Nutrition Institute in Association with the Faculty of Education the University of the West Indies and Training Colleges in the English-Speaking Caribbean 1987 pp 92-93.

BUDGETING FOR FEEDING THE FAMILY

A *budget* is a plan to help a person spend his/her money, time and energy wisely.

The advantages of budget planning are:

- helping people to buy only the items they need which removes the temptation to buy on impulse;
- enabling people to compare prices and to get the best value for their money.

When budgeting for the family, one must take the following into consideration:

- the family income, whether weekly, monthly or yearly;
- financial commitments, e.g. food, rent, school bills, utilities, etc;
- family goals and values;
- whether the family can "afford" something.

Budgeting does not mean "pinching pennies" and neatly recording how every one is spent, but it does mean that the family or individual will:

- be able to manage the money better;
- face money matters frankly and write down problems;
- consider the wishes and needs of each member of the family;
- agree on realistic plans for spending and saving;
- adjust plans as circumstances change.

Advertising often lures the unsuspecting consumer into purchasing non-essential goods which she cannot afford. The techniques used by the commercial advertiser such as catchy jingles, bright colours, attractive presenters and claims of benefits to be derived are all familiar. However, consumers should be aware of the power of advertising into forcing them to buy items which may be unnecessary or too expensive, and should be constantly on their guard. On the other hand, advertising can help consumers to compare benefits and cost of selected items.

Food is a major budget item. The "family food manager" should plan economical, nutritious meals and snacks that the family will enjoy.

Cutting costs and conserving human and other energy is not difficult, it just takes planning The steps are simple. Here are some of them:

1. **Plan the shopping**

   The shopper should always aim to get the best value for money. Planning the menu in advance so that it is known what foods will be needed, will help to guide the selections. A shopping list should be made – this will help in keeping to the set budget.

2. **Get value for money**
   - The food items should be looked at carefully, handled, checked for weight, inspected and prices compared before buying. The cheapest foods are not always the best.
   - Labels often give helpful hints and ideas on ingredient weights, how to prepare, use and store the food.
   - In most cases, larger amounts of the same item cost less per unit than the smaller sizes. But foods should only be bought in quantities that can be stored properly.
   - Tins that bulge, look rusty, dented, or have no labels at all, should not be bought because the contents of these tins can cause food poisoning.
   - Foods which are nutritious and have little or no waste are good value for money. If meat has more bone than lean, it isn't good value for money.
   - Vegetables should be examined carefully. Crisp, bright green, leafy vegetables, free from decay, mould, dirt and insects should be selected.

3. **Know the foods bought***
   - Consumers should be aware of the nutritive value of foods; what is compatible, so that they can make the necessary substitutions.
   - Using the six food groups as a guide will be helpful as within each group, foods can be substituted for each other.
   - Miscellaneous items such as sugars, sweets and condiments should be carefully chosen. Expensive items such as honey have very little more value than brown sugar.

***See Second Edition, "Food Budgeting for Caribbean Families", CFNI, 1985 and "Caribbean Foodways", CFNI, 1988.**

4. **Conserve in the kitchen**
   - Planning the meal before beginning to cook will help to save time and fuel energy. The refrigerator should not be opened too often because this utilises a great deal of electricity.
   - The right size pot should be used. It is wasteful to use a large pot when a small one will do.
   - Portions for more than one meal can be prepared and stored well for later use. Freezing is a good way to store if the meal is to be kept for several days.
   - One-pot meals conserve on fuel. Cooking methods can be combined, for example vegetables can be steamed while meat is being stewed, by putting the vegetables in a covered container, and resting it over the pot in which the meat is being stewed.
   - The oven can be used to prepare several dishes which can be stored for future use or used in one meal.
   - A pressure cooker helps to reduce cooking time, especially when cooking the feet, tail, head and intestines of animals or stewing beef, and dried peas and beans.
   - Soaking dried peas and beans before cooking will help them to cook faster.
   - Browning foods by the use of browning, soya sauce or burnt sugar, rather than cooking at high temperatures, conserves food value.
   - Lowering the flame after the pot starts to boil and keeping the cover on will save fuel and help the meal to cook in just about the same time as one done in an uncovered pot at a rolling boil. If the flame is put out or the heat turned off just before the food is cooked, and the pot is kept covered, the residual heat will complete the cooking.

5. **Meet the food needs of different family members**

   The types of foods bought for each member of the family may be the same, but the amounts will be different depending on their age grouping, gender, activities and general state of health. Following are guidelines which may be useful in meeting family food needs. They are applied in the section on a Lifetime of Good Nutrition. Decisions should be made regarding:
   - what will be served for a week or a day or more. This will depend on facilities available for storing foods, how many meals are eaten away from home, and available funds;
   - how these meals are to be prepared and served;
   - the types of food needed. (It is a waste to discard food which is bought and prepared, then not used because no one likes it);
   - the quantities of food that will be needed, whether bought, home-grown, or received as gifts. Foods which must be peeled or have seeds and stems, bone, fat or gristle removed, will have to be bought in larger quantities than those which have no waste. Less dry goods, e.g. cereals, dry salted fish, milk powder – will be needed than those which contain water, e.g. fresh fish, yam; or are all liquid, like fresh milk. Foods in season are relatively inexpensive;
   - planning each day's meals according to the multimix principle , will help ensure that the family will get a variety of foods. Less expensive foods can be chosen since all the foods in one group provide about the same amount of energy and nutrients;
   - meal service – meals, including a good breakfast, should be served regularly each day. Nutritious snacks for preschool and school children also need to be planned.

DETERMINING GOOD FOODS BUYS BY THE NUTRIENT-COST METHOD

When deciding how adequately a food can meet the daily requirement for certain nutrients and energy, four factors need to be considered:

1. The Recommended Dietary Allowances (RDA) for those nutrients and energy (Table 4). For ease of application, these

iii) Examples of Project and Test Questions

. Project. Family Planning Worksheet based on world population chart.
[Note: chart not reproduced here]

STUDENT WORKSHEET — WHY DO WE NEED FAMILY PLANNING ?

Study the chart which shows the change in world population over the last two hundred years.

Answer the following questions.

1. Is the world population increasing, decreasing or remaining about the same?

____

2. Which areas of the world show little increase in population?

____

3. Which areas of the world show the greatest rate of increase in population?

____

4. Give some reasons why the population has increased in these areas.

____

____

____

5. Are the figures given for the year 2000 the exact figures or estimated figures?

____

Why? _________________________________

____

6. The population of PNG in the last three censuses was as follows:-

1966: 2 150 000   1971: 2 435 000   1980: 3 010 000

Is the population of this country increasing, decreasing or staying the same?

____

7. To which areas of the world is PNG most similar, as far as change in population is concerned?

____

8. Write down some information about your family in the table below.

PARENTS	NUMBER OF CHILDREN BORN	NUMBER WHO DIED IN CHILDHOOD	NUMBER WHO LIVED OVER 40 YEARS
Your mother's parents			
Your father's parents			
Your parents			
Your older brother's or sister's (if any)			

9. Look at the tables filled in by other members of the class, so that you get a good overall picture of family size in your area.

Is the number of children born to each set of parents increasing, decreasing or staying about the same?

____

Is the number of children who die young increasing, decreasing or staying about the same?

____

Is the number of people who live to be over 40 years of age increasing, decreasing or staying about the same?

____

10. Give as many reasons as you can why the population of PNG is changing.

____

____

____

____

Source: Ministry of Education Papua New Guinea Science Growth and Reproduction Teachers Guide Grade 8 Unit 5. Boroko: Department of Education 1986 pp 104-105.

. Project. Issue of possible abortion of defective embryo.

Something to Discuss

Suppose your neighbor is expecting a baby. She wants to know if her child would be normal, so amniocentesis is performed. Karyotyping shows that the unborn child has Down's syndrome.

Q11. Would she have the child aborted or would she let the baby live? Why?
Q12. Do parents have the right, morally and legally, to terminate a pregnancy? Explain your answer.

Make a survey of the opinion of your classmates, your teachers, your parents, a priest, a nun, a lawyer, or anyone you know. Then, let you and your classmates have a discussion on the given questions/issues.

Source: Philippines Secondary School System Biology from Philippines Ministry of Education Culture and Sports Science and Technology II (Trial Edition) p 328.

. Project. Discussion questions on sex roles.

Discussion Questions

1. What makes a girl a girl, and a boy a boy?
2. Which of these differences are biological and which are cultural?
3. How are girls raised differently from boys?
4. What differences exist in your own homes in terms of how you are treated because of your sex.
5. Who cleans the house, wash the dishes, gets to stay out later? mows the lawn?
6. Are girls and boys treated differently at school? How?
7. Are there jobs that you consider only for men, or only for women.
8. Are your ideas of masculinity and femininity different from those of your parents?
9. Does the school assist individuals to develop their personality regardless of sex? Explain.
10. Do you ever wish to be of the opposite sex? Give reasons for your answer.
11. Who has it better in our society, men or women?

Source: Ministry of Education Jamaica Family Life Education Project Source Book for Teachers. Kingston: Ministry of Education 1986 p 54.

. Project. Definition of the family and its implications.

Let us examine these definitions of Family:

1. The family is a social group characterized by:

   common residence, economic cooperation, and reproduction. It includes adults of both sexes, at least two of whom maintain a socially approved sexual relationship and one or more children, own or adopted, of the sexually related couple.

2. The family is a social arrangement based on marriage and the marriage contract including recognition of the rights and duties of parenthood, common residence for husband and wife and children, and reciprocal economic obligations between husband and wife.

3. Note that the second definition rests on four terms namely: marriage and the marriage contract, reciprocal economic obligations between husband and wife, common residence and rights and duties of parenthood.

4. The family consists of two or more persons related by blood, marriage, or adoption. They share emotions and responsibilities, eat from the same pot, and they interrelate with one another and share the same culture.

From the definitions given answer these questions.

1. Which definition best fits the West Indian/Jamaican family? Give reasons for your answer.

2. Are all families based on marriage?

3. State the meaning of the following subsidiary terms of family:

   (i) common residence

   (ii) rights and duties of parenthood

   (iii) reciprocal economic obligations between husband and wife

   (iv) marriage and the marriage contract.

4. Identify family from the following groups by writing Yes or No

   (a) A group of boys living in separate rented rooms of a rooming house.

   (b) Some sisters living together and sharing expenses

   (c) A man, his daugher and her children living together.

   (d) A man, his wife, their children including an adoption.

   (e) Some brothers and sisters living together interrelating and sharing expenses

   (f) Grandfather, his daughter and her husband, their grown children.

5. Is marriage necessary for a family?

   Give reasons to support your answer.

Variety of Forms:

Families exist in a variety of forms depending on the society. Families are not always like Western or our Jamaican/West Indian family. In some societies the man could have many wives or the woman many husbands.

Is the Family Universal?

The Family is universal, and although existing in many forms it is the only institution that produces human beings, socializes them, nurtures them, and makes it possible for them to have their own children thereby continuing the process. Margaret Meade, noted American Anthropologist explains it better when she says:

> *The family is the toughest institution we have. It is in fact the institution to which we owe our humanity. We have no other way of making human beings except by bringing them up in a family – human beings able to act like men and women, able to marry other men and women and bring up children.*

Source: Ministry of Education Jamaica Family Life Education Project Source Book for Teachers. Kingston: Ministry of Education 1986 pp 56-57.

. Project. Functions of the Family.

Functions of the Family:

Although families differ in form according to the society, they nevertheless, are responsible for carrying out certain functions. The chief of these are:

1. Reproduction – for continuation of the species.
2. Socialization which includes education, religion and preparation for a career, learning social relationships, and management of leisure, being a responsible citizen.
3. Providing Basic Needs of:
   Food, shelter, clothing, health care
4. Transmitting the culture: the language, ideas, beliefs and attitudes, goals and values.
5. Preventing incest – by regulating relationships based on kinship.
6. Conferring Status:
   (a) derived – inherited like speech, education, relationships, family name, privileges.
   (b) acquired i.e. earned by the individual from the society.

Answer these questions:

1. Comment on the saying: "The Society determines the kind of familiy." Is this true of Jamaica? Give reasons for your answer.
2. Would you agree that the family is universal? Support your answer, yes or no, with examples.
3. In some societies the male or female is allowed many spouses. How do you see this arrangement operating smoothly in the Jamaican/West Indian society?

a) Examine the functions of the family and if possible add a seventh function.

b) Say how the family discharges the function of

(i) conferring status

(ii) preventing incest

(iii) transmitting the culture.

Source: Ministry of Education Jamaica Family Life Education Project Source Book for Teachers. Kingston: Ministry of Education 1986 pp 57-58.

. Test Questions

1) State what you understand by the term "family planning" and write a short essay explaining why family planning is usually considered to be necessary in (a) a developing country and (b) a developed country such as Britain or the United States.

2) A family works best as a group if each member of the family accepts certain responsibilities for roles to play and things to do to make the family a happy team.

   (a) Think about a typical family in your town or village and write down some of the special things the following people do to make the family a happy well organized group.

   Grandfather
   Grandmother
   Father
   Mother
   Baby
   Youngest child
   Eldest child
   Child with a younger and older brother or sister

   (b) Write a few sentences to describe what you do in your own famiy to help the family work together as a team.

3) Wise shopping is very important to make sure all members of the family get what they need at the lowest cost. Answer the following questions about buying food for your family. Write two or three sentences on each question.

   (a) Given the daily budget for food, what would you buy for the family meals for one day of the week?

   (b) When you are buying food how can you tell if the meals which will be prepared will be nutritious and value for money?

4) Write short essays on the following topics:

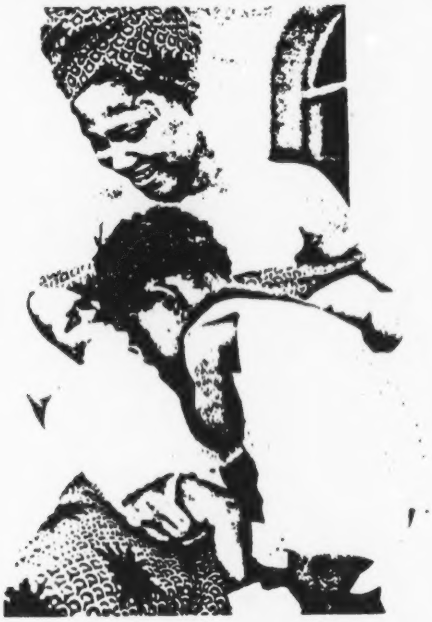
   (a) Comment on the saying: "The Society determines the kind of family". Is this true of our society? Give reasons for your answer.

   (b) Would you agree that the family is universal? Support your answer, yes or no, with examples.

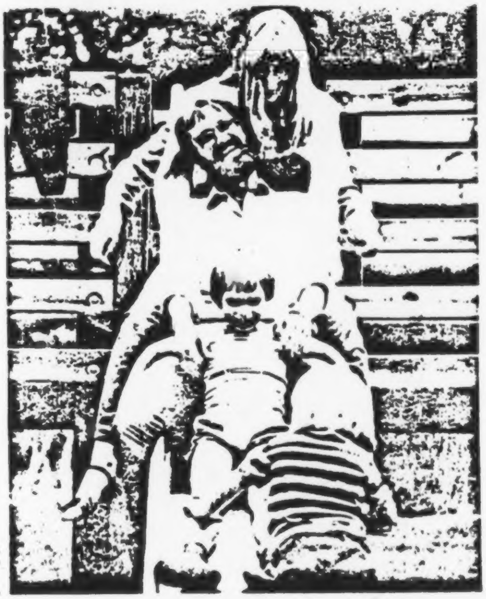
   (c) In some societies the male or female is allowed many spouses. How do you see this arrangement operating smoothly in our society?

   (d) List three functions of the family apart from those listed below. Say how the family discharges the function of
   (i) conferring status
   (ii) preventing incest
   (iii) transmitting the culture.

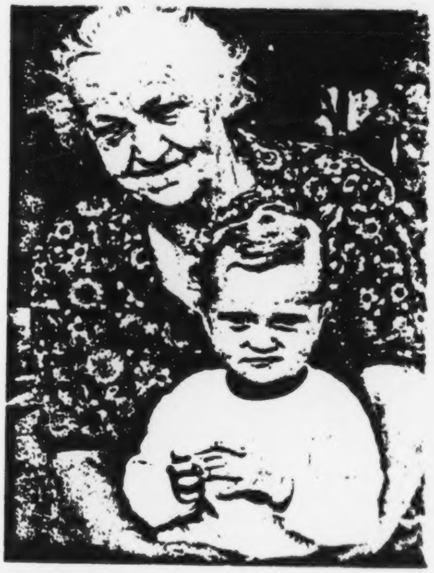
5) Here is a set of photographs of various family groups. Sometimes all members of the family are in a picture and sometimes only a few are included.
A question or questions is asked under each photograph. Answer each question in a few short sentences.



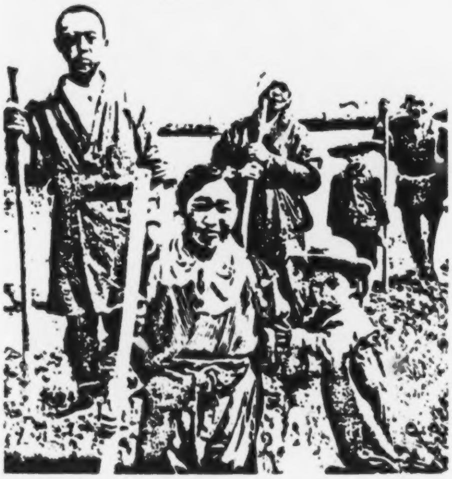
i) Why do you think the mother is smiling?



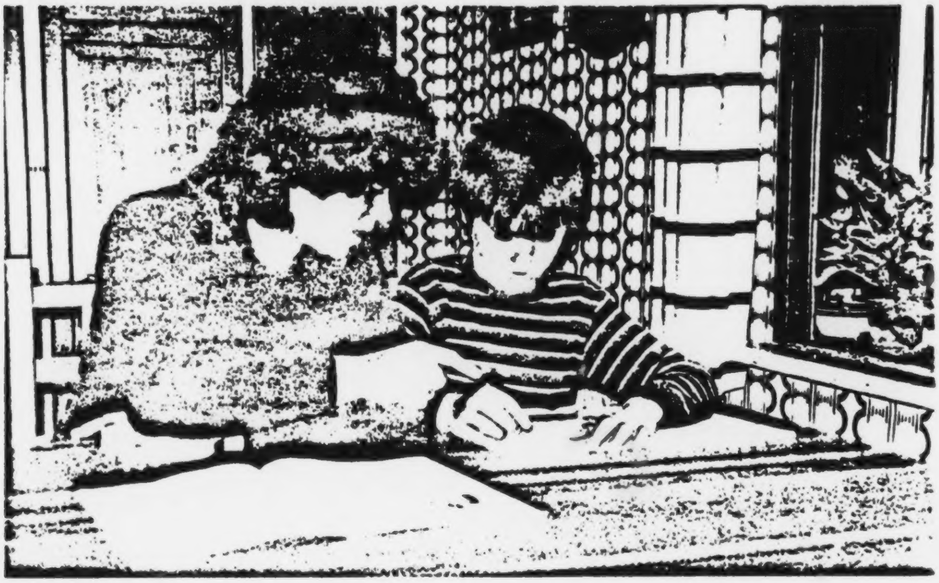
ii) Which members of the family are shown in this picture? What is the family doing? What responsibilities have the two grown up people accepted in the activity shown in the photograph?



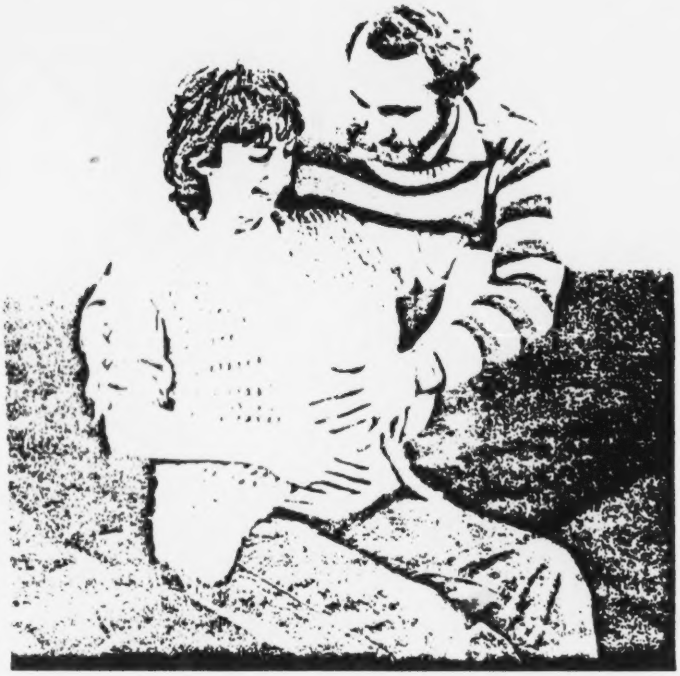
iii) These two people are members of the same family. What is their relationship? What responsibilities might the grown-up have in regard to the child?



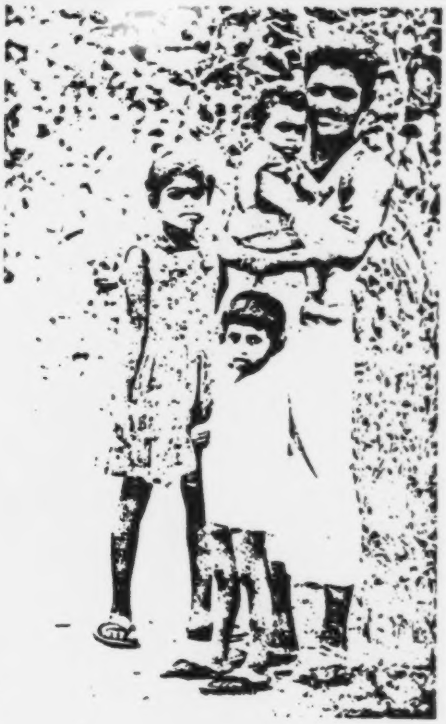
iv) These are all members of one family. List the family members present (father, mother etc.). What do you think the family group is doing? Give some advantages and disadvantages of the whole family working together in the way shown in the photograph.



v) Here is a mother with her son. What do you think each is doing?



vi) Describe this picture in as much detail as you can.



vii) Here is a father with three of his children. Give some possible reasons why the father is with the children rather than the mother.

Sources of Test Questions 1-5:

Question 4. Modified from Ministry of Education Jamaica Family Life Education Project Source Book for Teachers. Kingston: Ministry of Education 1986 p 58.

Photographs for question 5 from Kattmann, Ulrich *et al*. "Familien Bilder" Beihefter zu Unterricht Biologie No 110 December 1985.

Otherwise all aspects of test questions 1-5 are suggestions by the author.

7.5 Work and Vocational Issues

i) Rationale

Biology teachers are not necessarily specialists in vocational guidance counselling but share responsibility with all secondary school teachers in preparing potential school leavers for the world of work. In the specific case of biology this general aim can be achieved in several ways.

The first way is to indicate to learners how certain careers have a basis in biology. Professions such as agriculture, medicine, nursing and other paramedical careers, dentistry, veterinary science, pharmacy and biotechnology come immediately to mind. Other careers based on biology but requiring less demanding training could include farming, horticulture, fishing, game and national park management, woolclassing, beekeeping, occupational therapy, pest controlling, parks and gardens management and so on.

A second way of orienting students to the world of work is to help in setting up modest income generating activities at home, usually as part of a family cooperative enterprise. Commercial home gardening, small animal husbandry, chicken farming, beekeeping and using biological products for manufacturing craft or other objects are possibilities.

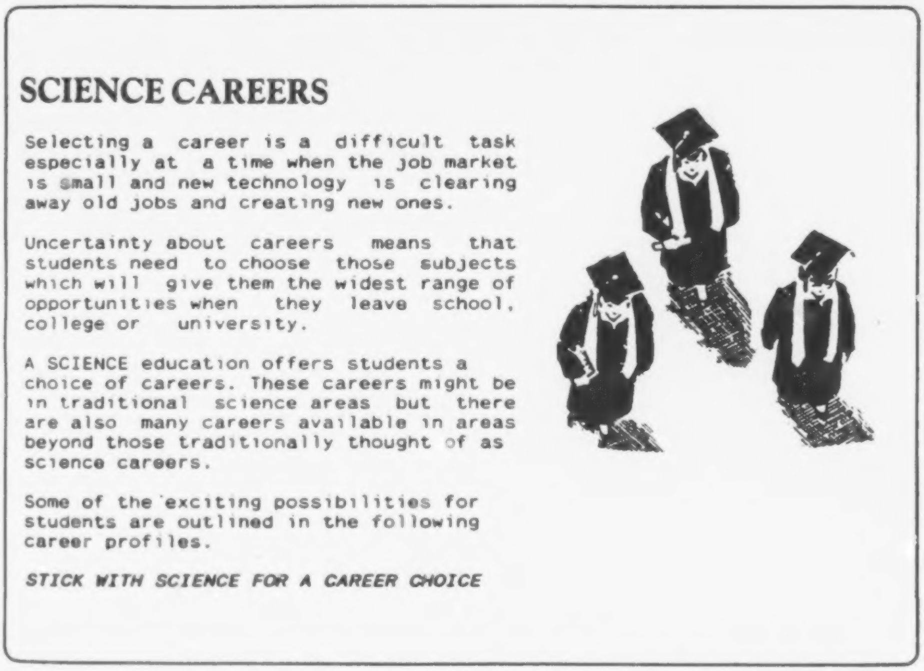
A third approach is to provide role models for students to help them understand how individuals become involved in biology based careers. This modelling can occur at two levels. The first is to review the career profiles of local people who have successful jobs in biology-based occupations. The second level is to examine the careers of famous biological scientists. In some cases these studies could be illustrated by visits of individuals to give talks to appropriate class groups and this is especially successful if people from the local community can be involved.

A fourth approach is to provide direct work experience for secondary students by allowing them to work in industry or commerce for two or three weeks as part of their formal curriculum. In the case of biology jobs can be found on farms and plant nurseries, in biologically based secondary industries, in medical services, science, journalism, food processing factories and so on.

ii) Examples of Content

Example 7.18: Choosing a science based career

School System: *Australia: secondary school science courses*
Approach: *A checklist of science based careers. Note this list covered chemistry and physics based careers as well as biology. It could be reduced to deal with biology alone, or alternatively given a biological focus by requiring students to discuss the degree of biological knowledge and skill likely to be involved in selected careers.*
Source: *Australian Science Teachers' Association (ASTA) "Science Careers" Australian Science in Schools Week Resource Book. Melbourne: ASTA 1988 pp 31-37*



SCIENCE CAREERS

Selecting a career is a difficult task especially at a time when the job market is small and new technology is clearing away old jobs and creating new ones.

Uncertainty about careers means that students need to choose those subjects which will give them the widest range of opportunities when they leave school, college or university.

A SCIENCE education offers students a choice of careers. These careers might be in traditional science areas but there are also many careers available in areas beyond those traditionally thought of as science careers.

Some of the exciting possibilities for students are outlined in the following career profiles.

STICK WITH SCIENCE FOR A CAREER CHOICE

USING YOUR SCIENCE SUBJECTS FOR CAREERS

You could be a marine biologist, architect, food technologist or dietician, a nursery worker, electronics technician, meteorologist, medical technician, forester, rural journalist or almost anything if you have chosen science subjects at high school.

The Department of Employment, Education and Training (DEET) provides a wide range of careers information through CES Job Guides.
The department's officers are willing to assist students examine science related careers and their pre-requisites.

Here is a summary of the information.

Group 1 = year 12 and degree/diploma or equivalent
Group 2 = year 12 and associate diploma /certificate, on-the-job training or equivalent
Group 3 = year 10 and formal or on-the-job training
Group 4 = no specific education. Usually on the job training.

*IMPORTANT Always check all subjects for career entry

DO YOU ENJOY OR ARE YOU GOOD AT

Have you considered the following occupations?

BIOLOGY?

Group 1

- Agricultural
  - economist
  - scientist
- Agronomist
- Anthropologist
- Aborculturist
- Audiologist
- Bacteriologist
- Biochemist
- Biologist
- Biophysicist
- Botanist
- Dentist
- Dietician
- Ecologist
- Entomologist
- Food technologist
- Forensic scientist
- Forester
- General nurse
- Geneticist
- Health educator
- Health Surveyor
- Horticulturist
- Landscape architect
- Marine scientist
- Medical
  - technologist
  - practitioner
- Medical specialist
- Nuclear medicine
  - technologist
- Nurse educator
- Occupational
  - therapist
- Oceanographer
- Optometrist
- Pathologist
- Pharmacist
- Physical education
  - teacher
- Physiotherapist
- Podiatrist
- Prosthetist
- Psychologist
- Radiologist
- Radiographer
- Science teacher
- Speech pathologist
- Tertiary lecturer
- Veterinary scientist
- Zoologist

CHEMISTRY?

Group 1

- Agricultural
  - scientist
- Agronomist
- Assayer
- Astronomer
- Bacteriologist
- Biochemist
- Biophysicist
- Botanist
- Chemical engineer
- Chemist
  - analytical
  - industrial
- Chiropractor
- Conservator
- Dentist
- Dietician
- Ecologist
- Entomologist
- Food technologist
- Forensic scientist
- Forester
- General Nurse
- Geneticist
- Geologist
- Geophysicist
- Horticulturist
- Industrial
  - designer
  - radiographer
- Marine scientist
- Medical
  - technologist
  - practitioner
- Metallurgist
- Meterologist
- Microbiologist
- Oceanographer
- Optometrist
- Pathologist.
- Pharmacist
- Pharmacologist
- Physicist
- Physiotherapist
- Podiatrist
- Radiographer
- Science teacher
- Tertiary lecturer
- Veterinary
  - scientist
- Zoologist

PHYSICS?

Group 1

- Agricultural
  - scientist
- Agronomist
- Architect
- Astronomer
- Audiologist
- Biophysicist
- Builder
  - professional
- Cartographer
- Dentist
- Engineer
- Forester
- Geologist
- Geophysicist
- Hydrographer
- Industrial designer
- Instrument
  - technologist
- Interior designer
- Landscape architect
- Marine scientist
- Medical laboratory
  - technologist
- Medical practitioner
- Metallurgist
- Mineralogist
- Meteorologist
- Microbiologist
- Naval architect
- Oceanographer
- Nuclear medicine
  - technologist
- Optometrist
- Patent examiner
- Pharmacist
- Physicist
- Physiotherapist
- Pilot
- Prosthetist
- Quantity surveyor
- Radiographer
- Surveyor
- Science teacher
- Textile technologist
- Town and regional
  - planner
- Tertiary lecturer
- Veterinary scientist

Group 2

- Animal laboratory technician
- Biological lab. technician
- Cardio-pulmonary technician
- Community health nurse
- Dairy technologist
- Dental hygenist
- Dental nurse
- Dental therapist
- Farm manager
- Food processing technician
- Health surveyor
- Medical laboratory technician
- Mental health nurse
- Naturopath
- Nuclear medicine technician
- Pathology technician
- Viticulturist

Group 3

- Ambulance officer
- Audiometrist
- Beauty specialist
- Childcare worker
- Dental attendant
- Dental technician
- Dairy inspector
- Enrolled nurse
- Farmer
- Farm produce inspector
- Farrier
- Fisheries inspector
- Fruit inspector
- Furrier
- Gardener
- Hairdresser
- Laboratory assistant
- Meat inspector
- Optical technician
- Pharmacy assistant
- Veterinary assistant
- Woolclasser

Group 4

- Bee keeper
- Farm hand
- Hatchery assistant
- Herd tester
- Medical orderly
- Occupational therapy assistant
- Parks and gardens attendant
- Pest and weed controller

Group 2

- Biological lab. technician
- Building surveyor
- Dairy technologist
- Farm manager
- Food processing technician
- Gemmologist
- Geoscience technologist
- Health surveyor
- Instrument technician
- Laboratory technician
- Photographer
- Telecommunication technician

Group 3

- Aircraft trades
- Ambulance officer
- Automotive electrician
- Beauty specialist
- Cook or chef
- Computer service person
- Dental assistant
- Dry cleaner
- Dyer
- Electrical fitter
- Electrical mechanic
- Electroplater
- Enrolled nurse
- Furniture polisher
- Hairdresser
- Laboratory assistant
- Motor mechanic
- Office machine mechanic
- Optical mechanic
- Painter and decorator
- Panel beater
- Plumber and gas fitter
- Printing trades
- Refrigeration mechanic
- Scientific instrument maker
- Sheetmetal worker
- Silkscreen printer
- Silversmith
- Spray painter
- Stonemason
- Veterinary assistant
- Welder
- Woolclasser

Group 4

Group 2

- Airtraffic services
- Building surveyor
- Draftsperson
- Gemmologist
- Instrument technician
- Laboratory technician
- Electronics technician
- Photographer
- Radio officer (ship)
- Radio technical officer
- Survey assistant
- Telecommunications technician

Group 3

- Aircraft trades
- Automotive electrician
- Audiometrist
- Building technician
- Cardiac technician
- Computer mechanic
- Dental technician
- Electrical fitter
- Electrical mechanic
- Electroplater
- Fitter
- Gunsmith
- Instrument maker/repairer
- Laboratory assistant
- Motor mechanic
- Meteorological observer
- Optical mechanic
- Office machine mechanic
- Plumber and gas fitter
- Radar plotter (RAN)
- Radio tradesperson
- Refrigeration mechanic
- Sheetmetal worker
- Shipwright and boat-builder
- Telecommunication tradesperson
- Turner
- Watch and clockmaker
- Welder
- Printing trades

Group 4

- Boiler attendant
- Plant operator

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Example 7.19: Local identities as role models for a biology-based career

School System: Australia: secondary school science courses
Approach: Career profiles of a group of young local identities to illustrate educational background required and nature of work performed in a selected range of biology based occupations
Source: Australian Science Teachers' Association (ASTA) "Science Careers" Australian Science in Schools Week Resource Book. Melbourne: ASTA 1988 pp 31-37

TREVOR DOWLING,
Technical Officer CSIRO
Div. of Water Resources

I work in a team that is looking at one part of a major Australian problem, vegetation growth and soil salinity. We are helping Australia's agriculture and assisting environmental conservation (a greenie in disguise).

The work our group does is necessary if we are ever to "rehabilitate" this land so that it can again grow a range of plants instead of being a barren, sparsely vegetated wasteland.

I'm a Technical Officer. This means that I didn't need a degree to get a job but many positions like mine are filled by people who have a degree. Before long I will be able to move into the Experimental Scientist range and this will give me even greater career opportunities.

I went to a government school in Canberra and was most interested in Science and Geography. I obtained a degree in Geography from the Canberra CAE. This involved a great deal of cartography (mapping, often using computers).

I help enter experimental data into the computer and use the information to develop models and write programs to produce maps and graphs.

This mapping has come in handy to help with my interest in orienteering. I not only enjoy competing but have produced a number of orienteering maps.

I've recently completed a diploma in computing while working for CSIRO.

The job has provided quite a few opportunities to travel to fascinating parts of Australia and the U.S.A.

LINDA COOPER,
1989 SHELL QUESTACON SCIENCE CIRCUS Coordinator with the ANU National Science and Technology Centre.

Linda graduated from the Newcastle University in 1987 with Science and Arts degrees gained over a four year study period. In 1988 Linda was one of the young graduates who formed the team of 'Explainers' for the NSTC's SHELL QUESTACON SCIENCE CIRCUS. The 9 were enrolled in a one year post graduate Certificate in Science Communication course established at the Australian National University in Canberra. The Circus is the major practical component of the Certificate course.

Linda found involvement with the Communication course and Science Circus sufficiently stimulating to apply successfully for the coordinator position for 1989. Linda is therefore working with the 1989 team of 11 graduates and advises and coordinates the work associated with the Certificate course.

The Circus travels widely in Australia and is effectively on the road for 5 months. Over two years Linda will see lots of Australia while enjoying the many opportunities available to develop her communication skills, meet a wide range of Australians and decide on her future. This is highly likely to be in work which will enable Linda to utilise her Science and her communication skills.

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LOUISE RICE
Publisher, Heinemann Educational Australia.

This job involves talking to teachers and consultants in all subject areas, visiting schools and conferences, signing up authors and helping with the preparation of final manuscripts Louise also has to work with a team of editors, book designers, and a publicity and marketing department to turn the manuscripts into books and to make sure teachers hear about them. She is responsible for the overall financial control of the books she publishes. She also travels to Sydney, Adelaide, Perth and Brisbane from her base in Melbourne.

Louise joined Heinemann Educational in London in 1980 after graduating with an honours degree in Biology from the University of Southampton. She began in the Science and Maths publishing department as an Editorial Assistant. She joined the Australian company in August 1987.

When Louise is not at work she enjoys eating out in Melbourne's innumerable cafes and restaurants with her friends.

ROSEANNE CASU,
Molecular Biologist, CSIRO Div. of Tropical Animal Production

Science, to me, meant excitement and mystery.

I completed my high school education with teachers who encouraged students to explore the possibilities of science - oriented careers. After a flirtation with foreign languages, I settled on a science career.

In common with many students I did not decide on my major, biochemistry, until second year university. To this I added all the genetics subjects I could take and graduated from the University of Queensland in 1983 with a Bachelor of Science.

By this stage, genetics had become an all absorbing interest. I completed a Masters qualifying in genetics and then embarked on a masters project on the rate of evolution in various species of fruit fly. My supervisor encouraged me to convert my enrolment to a Ph. D. degree which was awarded in 1988.

In 1987, I was fortunate enough to get a job as an experimental scientist with CSIRO working in molecular biology in the area of vaccine research. This was a change in tack for me and required some high-speed learning of what seemed to be a totally different language.

I find molecular biology to be a stimulating area to work in and the many and varied techniques we use definitely fulfil my love of practical work, a trait I put to good use in two of my hobbies, fashion and music.

I have now settled on molecular as the branch of science I wish to work in, a change from my original ideas, which illustrates the advantage of a broad-based science education.

ROBLYN JOSEPH, *Technical Officer, CSIRO Division of Wildlife and Ecology.*

I grew up in a small country town in the Riverina of NSW. I attended the Wagga Wagga State High School. The school population was 1300 when I began in year 8 and it was something of a culture shock.

I completed my HSC, and studied Chemical Engineering for eighteen months at Sydney University, after which I started working for the CSIRO.

The Division of Animal Production investigates the methods of animal husbandry for the major economically important animals in Australia, particularly sheep. The aim is to achieve high yields of good quality products using good management practices.

A project I worked on was biological defleecing. The aim of this project was to find an inexpensive, relatively easy way to "shear" sheep. We used a small protein obtained from the salivary glands of mice to make the sheep's wool weak evenly across the whole fleece so that it is easy to pull off.

I now work at the Division of Wildlife and Ecology, where I am involved in a project to study the control of lactation in the wallaby.

My after work hours are divided between studying for a degree, training my German Shepherd dogs, instructing at a local Dog Obedience Club, and going to my farm. The farm has an area of natural bushland, which supports over 35 species of birds, grey kangaroos, swamp wallabies, brush and ring tail possums and goannas. I intend to learn cabinet making when I find some spare time.

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Example 7.20: Crop rotation

School System: Zimbabwe: secondary school biology
Approach: Text to illustrate the scientific basis of one aspect of local employment - namely crop farming
Source: Ministry of Education Zimbabwe Science in Agriculture Module 1 The Soil ('O' Level Study Guide). Harare: Curriculum Development Unit of the Ministry of Education 1986 pp 65-66.

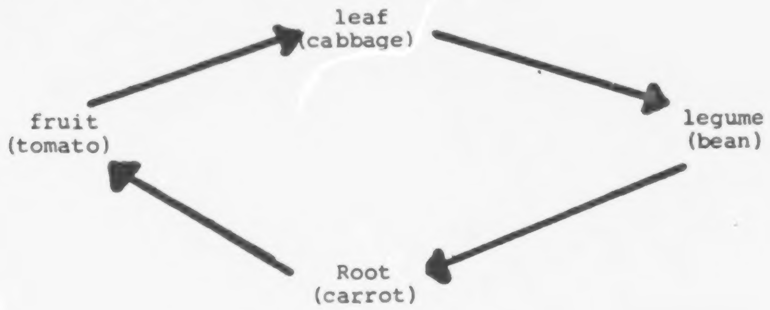
CROP ROTATION

Crop rotation is a method of farming in which the same piece of land is kept busy with the crops following a definite order which might be seasonal or annual. Normally the order depends on the time in which the next crop thrives and the former crop is to be harvested. This order is aimed at maintaining or restoring nutrients in the soil.

Criteria used in scheduling a crop rotation.

1. Effect of the crop on the soil in which it is growing
   a) Some crops, called 'heavy feeders' are exhaustive i.e. take a lot of nutrients from the soil e.g. maize, yams, carrots, cabbages etc.
   b) Some crops, especially legumes, add nutrients i.e. nitrogen into the soil and these should actually follow 'heavy feeders'.
   c) Other crops which might follow the 'heavy feeders' are the 'light feeders', which take very little amounts of nutrients e.g. tomatoes and pumpkins (fruits.)

Approved Vegetable Garden Crop Rotation



The table below summarises the properties which may be used to determine the sequence of crops in crop rotation.

CABBAGE	BEANS	CARROT	TOMATO
1. deep rooted	shallow rooted	deep rooted	shallow rooted
2. heavy feeder	soil improver	heavy feeder	light feeder

Therefore the properties of the crop arranged in the above order make the rotation a successful one.

Crop rotation is not just concerned with the land itself and its proper usage. There are of-course many other methods of crop rotation. They depend on many factors such as the soil type, and needs of the farmer, the climate and the number of crop the farmer grows. But did you ever stop to think why crop rotation is important ? Can you say why crop rotation is so important to the farmer ? Discuss this with your teacher. Perhaps you might need to ask an expert from Agritex on this. Write down what you find.

Example 7.21: Catching and preserving fish

School System:	*Philippines secondary schools*
Approach:	*Description of teaching modules designed to help students farm/catch fish and process them for sale. The emphasis is obtaining an employment skill which can be utilized immediately at home with family cooperation*
Source:	*University of the Philippines Fish Conservation and Preservation (A series of four modules). Manila: Science Education Center University of the Philippines supported by UPSEC-UNICEF Project "Survival of the Family" 1978 Preface.*

Part 1 Getting To Know About Fish provides information, descriptive and/or illustrated on the following: fishes common in the Philippines and their habitats; parts of a fish and their corresponding functions; some common poisonous fishes; and, reproduction or spawning.

Part 2 Pollution and Conservation is intended to motivate its readers to adopt practices which conserve the sea and other bodies of water as sources of food and livelihood. The causes and effects of water pollution on fish and men eating the infected fish are described. The reasons behind the prescribed regulations for the conservation of marine resources in the Presidential Decree 704 are also discussed.

Part 3 Fish Preservation by Salting describes the dry method of salting fish, the product of which is preserved salted fish with translucent and firm yet tender and soft flesh. The climate in the Philippines has been considered in the prescribed procedure. Communities where there is an oversupply of fish can avail themselves of this procedure that yields preserved fish comparable to fresh fish when cooked. Included in the module are some recipes, too.

Fish Preservation by Salting comes in two editions: a) a nontechnical edition intended for the general public; and, b) a technical edition intended for students. The latter contains a self-test to check the learner's understanding of the technical terms included in the module.

These modules have been prepared to answer some of the needs of San Salvador, a fishing community and the site of the UNICEF-supported project entitled, "Survival of the Family." Other fishing communities and schools in this type of communities can use these materials to provide closer links between learning in the school and learning in the home and the community. Secondary and tertiary schools may use them as resource materials and/or learning units. Written in an expository way and well-illustrated, the materials are comprehensible to readers with varied science background.

Example 7.22: Work experience

School System: Australia - especially school year 10
Approach: Extract from a descriptive article on the characteristics and organization of work experience for school students
Source: Meyer, G. Rex "Work Experience for Pupils in Formal Education: Principles and Practice" in Waddington, D.J. Education, Industry and Technology (Science and Technology Education and Future Human Needs Volume 3). Oxford: Pergamon Press for the ICSU Press 1987 pp 355-361.

Definition

The Department of Education in New South Wales defines work experience as "a tool or technique which can be used in the social development of students. It involves participation by students in work situations while they are still attending school. Its purpose is to assist students through the transition from school to the working life of the community."

Other educational systems open the approach to higher levels of education. The Tasmanian Department of Education states that "work experience is an integral part of a school or college's Participation and Equity Programme conducted for students enrolled either part-time or full-time. Such programmes involve those periods of participation . . . by students in work situations."

There is no reason in principle why the definition could not be extended to cover all levels of a formal programme of education. No doubt, however, the most critical level is the last year of compulsory schooling which in Australia is School Year Ten (secondary school form 4). Nevertheless work experience programmes are also important in senior secondary school, technical education, university and so on. At these levels, however, the objectives of work experience may be somewhat broader in aim, not only helping in transition from formal education to the working life of the community, but also in substantive areas of the curriculum such as a university course in industrial chemistry or a technical college programme in motor mechanics.

In recent years there has been a worldwide trend towards developing stronger links between formal education and the world of work. Vocational education, in the broadest sense of that term, has had a long tradition of contributing to personal development and to general education, particularly in the secondary school. In most countries, however, perhaps with the exception of the United States of America which has demonstrated successful practice in this area since the turn of the century, direct work experience as part of a formal educational programme is a relatively new concept, especially at school.

Aims of work experience

Most school systems in Australia limit work experience for each pupil to only one or two weeks, usually in School Year Ten. They do however build this in to a more extended programme of transition education and therefore tend to claim that the experience has the following types of aims.

"— to break down the barriers between school and work
— to give students some knowledge of a variety of employment fields
— to give students an appreciation of the function and nature of work in our society
— to help students gain a greater knowledge of themselves enabling them to make a more realistic assessment of their abilities
— to provide new aspirations for the less motivated student
— to heighten awareness of the role education plays in future vocational pursuits
— to involve both parents and employers in the school to work transition"

The implication is that work experience breaks down barriers between life at school and life in the community at large. Barriers to this have been identified: (i) isolation from the reality of work; (ii) lack of skill by students in evaluating their personal strengths and weaknesses in relation to vocational decisions; (iii) low level of student confidence and social competence because of the isolation of the school environment; (iv) limited opportunities for parents, teachers, employers and students to interact about issues such as further education, employment and unemployment and (v) failure of the academic curriculum to prepare students for the work environment and to enter the labour force.

Organisation

Most work experience activities, including school based programmes in Australia, are organised in the following way.

Selection of Students. "Work experience programmes have relevance for all levels of ability and will have a different emphasis depending upon students' needs." Ideally, therefore, all students of a particular educational institution should be involved. Where places are competitive however priority should be given to potential early leavers. Matching of students and jobs is usually done in consultation with other teachers, guidance officers and the administration; with students' home address, academic record and career preferences being important criteria. Most institutions establish waiting lists of students who can be placed as positions become available.

Selection of Employment. Most systems recommend that institutions keep a register of successful work experience placements. Criteria for selecting employment frequently include the following.[3] It is important that

"— the student is in no moral danger (situations of special concern include placing girls in factories where there are few other women or billeting students with farm workers);
— the student is not asked to carry out any work too difficult for his or her physical strength;
— the student is not exploited as cheap labour to do tasks with no educational value;
— the student is not occupying a position to the exclusion of a full-time worker;
— the student is given no responsibility beyond that which could be reasonably expected."

In addition it is desirable to select employment with some relevance to a substantive area of the curriculum. Most institutions mount public relations programmes to attract potential employers by stressing benefits to commerce and industry.

iii) Examples of Project and Test Questions

. Project. Choosing a Career. There are three broad areas of careers. These are careers mainly concerned with (1) people (2) things and (3) ideas. The following table lists just a few examples.

People	Things	Ideas
1. Medicine Doctor Nurse Psychiatrist Pharmacy	1. Manufacturing Machine Operator Food Processor	1. Fine Arts Illustrator Artist Interior Designing Model dancer
2. Education Teacher Counsellor School Principal	2. Transportation Truck driver Bus driver	2. Politics Politician
3. Social Worker Probation Officer Psychologist Community development officers	3. Communication Air pilot, stewardess Telephone operator	3. Legal Lawyer
4. Mass Media Announcers – radio and Television	4. Plants Farming and Agri-business Horticulture Forest ranger	4. Religion Clergyman, Priest
5. Business Business manager Accountant Secretary Clerk		

Form discussion groups of four and five. Discuss the following questions.

i) Which of the above careers deal mainly with living things?

ii) Which of the above careers could involve some knowledge and understanding of biology?

iii) Add at least two other careers to each column which would require a good knowledge and understanding of biology.

Each member of the group should then say which type of career he or she would like to follow and why. Elect a spokesperson and report a summary of your discussion to the class as a whole.

Source: Suggestion by author. Source of table: Ministry of Education Jamaica *Family Life Education Project Source Book for Teachers*. Kingston: Ministry of Education 1986 p 78.

- Project. Understanding scientific basis of one aspect of local employment - animal production.

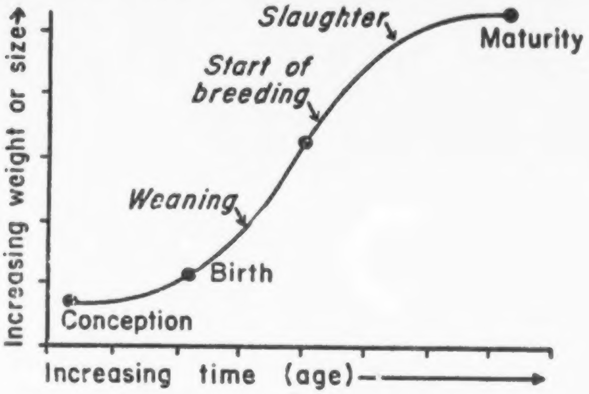
CONVERSION EFFICENCY

Farm animals that are reared for economic reasons are fed on food types that can be measured. If the animals can be measured to find out their increase in mass, it should be possible to determine the amount of food that is fed to an animal before it gains a unit mass. In agriculture this is what is termed CONVERSION EFFIENCY. The animal converts the food into its own flesh.

Some animals are obviously better than others and if farmers want to make a quick profit they should be aware of which animals have such a good conversion effiency.

Conversion effiency of live animals can be obtained from growth curves made by plotting graphs of live weight gain against time. Such growth curves could be used for other things such as determining the most opportune time when animals kept for meat should be slaughtered.

Generally animal growth curves are S-shaped i.e. they are sigmoid in shape as shown in the diagram below.



Growth is slow soon after birth and it quickly speeds up. This period of rapid growth is called a 'grand' period of growth. The graph then slows down as the animal reaches maturity. From this growth curve, can you say when the food conversion effiency of the animalsisi) highest (ii) lowest?

When is it most convenient to slaughter your animals for meat? Discuss this with your teacher.

Source: Ministry of Education Zimbabwe Science in Agriculture Module 3 Animals. Harare: Curriculum Development Unit of the Ministry of Education 1986 pp 18-19.

. Project. Understanding businesses and industries.

Activity

Your class will be divided into small groups. Within each group, consider the following types of businesses and industries that have supported many people in many places. Try to identify the major business or industry pictured in each of the photographs. Each industry has played an important role in the economic growth of the city in which it is located. Why do you think this has happened? How has this business or industry influenced land use in the area?

LOUNGE
FOUR
QUEENS
LOUNGE
SNACK BAR

Source: Biological Sciences Curriculum Study Investigating the Human Environment: Land Use. Colorado Springs: BSCS 1984 p 53.

Additional discussion questions suggested by author.

1) List some of the careers which may be available in each of the industries illustrated.
2) Select one job from each industry for which it would be helpful to know something about biology. Explain why.

. Test Questions

1) Of the following which career depends mostly on very thorough knowledge and skill in biology?
   A. engineer
   B. architect
   C. doctor
   D. lawyer

2) Write two sentences on each of the following careers to show how some knowledge of biology would be helpful in that career.
   Tour guide
   Science journalist
   Farmer
   Gardener
   Plumber

3) Some people say that science and the arts are very different, but it could be argued that they are really closely related. For each of the following state how a good knowledge of biology could help the person involved do a better job. Write only two or three sentences on each.
   Artist (painter)
   Pop music performer
   Music composer
   Writer
   Landscape designer

4) (a) Write an essay on the career you would like to follow when you leave school.

   (b) Give an account of how you think a knowledge of biology may help in your future job.

   (½ marks for each part of question 4)

5) If you were a crop farmer you would probably be more efficient if you understood something about biology. Write five lines on each of the following topics to show how a farmer could gain from knowing about that topic.
   (a) Photosynthesis
   (b) Carbon cycle in nature
   (c) Ecological adaptation
   (d) Soil erosion
   (e) Transpiration

Source: Test questions 1-5 suggestions by author.

7.6 **Bioethical Issues**

i) Rationale

In school biology courses committed to a focus on social issues bioethical considerations emerge as inevitable outcomes of the teaching (7). According to the American educationalist Joseph McInerney the approach to the teaching of bioethical issues should be through an analysis of underlying biological concepts which can help to "direct the evaluation and synthesis of information into meaningful contributions to human welfare and effective citizenship" (8). Professor Peter Kelly of Southampton University, UK, agrees with McInerney but stresses that in addition to purely cognitive aspects bioethical analysis must also consider emotional components and that an empathetic approach is essential (9).

Advances in biotechnology such as gene splicing and in human reproductive physiological (in vitro fertilization, surrogate motherhood, experiments with embryos etc.) just to mention two areas, have raised serious ethical questions in society. A socially sensitive programme of school biology, therefore, must address these issues.

The Education Commission of the International Union of Biological Sciences has advocated that school biology courses should deal with sensitive bioethical issues. At a meeting of the Commission in Helsinki in September 1986 topics which might be suitable for introducing bioethical problems were identified. These topics are listed in the following box (10).

School Biology Topics Suitable for
the Introduction of Bioethical Issues

A. Animal Structure and Functions

1. test tube babies
2. gamete banks
3. surrogate motherhood
4. artificial insemination by donor
5. transplantation of organs
6. foetal freezing
7. abortion
8. contraception
9. untested food additives
10. use of growth hormones in food production
11. mercy killing of incurable cases
12. drug abuse
13. transfusion of blood

B. Genetics and Evolution

14. human cloning
15. animal cloning
16. sex selection
17. genetic engineering for biological warfare
18. genetic counselling
19. human inbreeding
20. eugenics
21. gene splicing
22. experimental human chromosomal manipulation
23. birth control based on genetic information
24. in vitro fertilization
25. definition of personhood
26. definition of human being
27. experiments with human foetal tissue

C. Evolution and Diversity

28. experimental attempts to create life from the non living
29. creation of new species by biological engineering
30. human responsibility to other species
31. racism

D. Plant Physiology

32. use of defoliants
33. pesticides
34. bacteriologic weapons
35. use of poisonous substances in food
36. use of hormones in food production

E. Ecology

37. social, economic and technical development
38. monoculture of economic crops
39. management of natural resources
40. conservation of wild life
41. conservation of ecosystems
42. ecological alteration
43. alteration and degradation of the natural environment
44. population control
45. pollution of environment
46. alternative resources
47. energy conservation
48. management of local resources
49. recycling material resources
50. urbanisation

F. Behaviour and Social Applications

51. living with cultural diversity
52. mental illness
53. aged persons in society
54. disabled persons in society
55. animal experimentation
56. experiments with humans
57. responsibility for family relationships
58 single parents
59. children without parents
60. attitudes to use of energy
61. attitudes to use of natural resources
62. consumerism
63. criteria for defining death
64. life style
65. stress
66. self reliance
67. behaviour modification
68. confidentiality of personal information
69. access to information
70. quality of information
71. indoctrination in society

In regard to methods of teaching most educators working in this area (11) agree that a case study approach should be followed. Each case should examine (i) the underlying biological facts of the case (ii) the conflicting views of interested parties (iii) the possible reasons for the views held and (iv) the social implications and consequences of any policies adopted (12). It is also generally agreed that teachers should not impose "solutions" to bioethical problems but that students should be encouraged to make up their own minds based on a careful analysis of each particular case.

ii) Examples of Content

Example 7.23: Case study analysis - termination of pregnancy when infant is at risk

School System: USA - secondary school biology
Approach: Teachers notes for a case study involving Huntington Disease
Source: Biological Sciences Curriculum Study (BSCS) Basic Genetics Students Book Teachers' Materials. Colorado Springs: BSCS 1988 pp 33-34.

Focus

The reading provides an opportunity to continue discussions of ethical issues in genetics. The research discussed in this activity is considered a milestone not only in research on Huntington disease but also in the use of DNA markers to locate genes of interest in general. The ethical questions raised demonstrate problems created by rapid progress in genetics.

Objectives

Students will have an opportunity to read about the use of classic linkage studies and recombinant DNA technology in gene mapping, and to consider the possible psychological outcomes of learning that one will develop Huntington disease in later life.

Materials and Advance Preparation

You may wish to review the behaviour of chromosomes during meiosis in general, as well as the concepts of crossing over and linkage. Students may review the section on meiosis in the introductory activity "Living with Cystic Fibrosis". Diagrams of crossing over are available in any genetics text and in most high school biology texts.

Notes

One ethical dilemma here involves a conflict between the duty of "truth telling" and the goal of "do no harm". Inherent in the argument in favour of truth telling is the notion of autonomy, the right of an individual to make his or her own decisions and to have access to all the necessary information so that such decisions are well-informed. The argument in favour of truth telling asserts that people are better off if they are told the truth, and, in fact, that more harm may be done in withholding the truth than from revealing it. The argument in favour of withholding the truth asserts that people cannot handle devastating news and that too much harm is done in telling them the truth.

Another dilemma involves the ability to detect the HD gene prenatally. All of the general concerns about abortion apply in this situation, but they are complicated by the late onset of the disorder. Should one terminate a pregnancy when the child that would otherwise result would likely have more than 35 productive years? You may wish to point out that James Watson was 23 when he helped delineate the structure of DNA. Marie Curie won her first of two Nobel Prizes at the age of 36. On the other hand, it is morally defensible knowingly to bring a child with a fatal genetic disorder into the world.

Directions for Conducting the Activity

Getting Started

Summarize the situation for your students as follows: "Huntington disease is an extremely serious genetic disorder that is inherited as an autosomal dominant. The children of an affected person have a 50% chance of having a disease themselves. The disease involves loss of control over body movements (chorea), loss of speech, degeneration of the brain and central nervous system, apparent dementia and death - usually after about 15 years of deterioration. The disorder does not usually make an appearance until about age 35 or older. Until recently - with the publication of the research findings you will read about - there was no way to determine which of the persons at risk would actually develop the disorder. As you can imagine, living with the uncertainty is very difficult for many persons who are at risk. On the other hand, some individuals may not wish to know for certain that they will develop the disorder."

Have students read the section of the activity that describes the research. Make certain they understand linkage and the use of restriction enzymes to produce DNA fragments. You might find it necessary to review meiosis, crossing over, and DNA base sequences. When you feel confident that students understand the basis of the research, ask them to read the section of the activity that presents the ethical dilemmas.

When you feel confident that students understand the seriousness of the situations presented, organize students in teams of three or four to continue with discussion of the questions that follow.

Questions for Discussion

1. Identify the various goals, rights, and duties involved in this situation. (Students may, at first, concentrate on what they perceive as the inviolate right of an individual to know the truth and make up his or her own mind about what to do. Other notions are involved, however, including the physician's duty to do no harm to the patient and the goal of preservation of life.)

2. List arguments against telling people that they will develop the disorder. Which of these points could be verified or refuted through research? (Some people believe that if individuals are not psychologically capable of handling the knowledge that they do indeed have the disorder. Some argue that suicide might result. The outcomes of telling people could be documented, but there is a strong argument that such research is unethical and inhumane. Medical experimentation should never be conducted to find an answer at the cost of human life or suffering.)

3. List arguments for telling people they will develop the disorder. Which points could be verified or refuted through research. (Some people believe that individuals informed that they will develop HD can have hope and that they will be able to handle the information. Once informed, individuals can make plans and decisions on the information they have received. These arguments might also be researched, but they have the same ethical problems as those listed in number 2.)

4. Suppose that neither argument is totally correct. Assume, for the sake of discussion, that there are some situations where it might be better to know and other situations where it might be better not to know. Who should decide? Parents, other family members, physicians, psychologists or psychiatrists, the government, the individual who is at risk, or someone else? At what age should an individual be given this information? Is it hard to decide who should decide? (Yes - students should realize that the decision of who decides is as difficult as the decision itself. In this case, you may hear arguments that some individuals or classes of individuals have inherently greater "rights", "qualifications", or "control over a situation" than others. These are judgments and, sometimes, social norms. They are not facts, and cannot be treated as such.)

Extensions

Although the preceding discussion has purposely avoided personal perspectives, students may wish to explore their own feelings. Questions for discussion might include the following:

If you were at risk for HD, would you want to know?
Do you think parents should tell their children of their risk?
If so, when and how?
If you were at risk, would you marry? Have children?
What career choices would you make?
How would you feel about yourself and others?
In the case of prenatal diagnosis, do you think a couple should abort an infant who will develop HD perhaps 35 years later?

Example 7.24: Selected issues suitable for bioethical analysis

School System: Australia - secondary school biology.
Approach: A list of ten events useful for case study analysis
Source: Brumby, Margaret "Teaching and Learning About Issues in Biology" Unesco: New Trends in Biology Teaching Volume V. Paris: Unesco pp 45-57.

INTRODUCTION

1975	**Karen Quinlan**	▪ *comatosed aged 17 following a drug overdose, placed in intensive care*
1978	**Louise Brown**	▪ *the first baby born using* in vitro *fertilization*
1981	**Great Barrier Reef of Australia**	▪ *placed on the World Heritage List*
1982	**'Supermouse'**	▪ *the mouse that grew to the size of a rat; successful cross-species gene insertion of a rat gene (for growth hormone) into a mouse embryo*
1982	**Southwest Tasmanian Wilderness**	▪ *placed on the World Heritage List*
1983	**Barney Clark**	▪ *the world's first artificial heart transplant recipient, died 112 days later*
1984	**David**	▪ *the 'boy in the bubble', died 15 days after leaving his sterile home of 12 years, following a bone marrow transplant*
1984	**Zoe**	▪ *the world's first baby born following freezing as an embryo*
1984	**Baby Fae**	▪ *the world's first baboon heart transplant recipient, died 21 days later*
1985	**Karen Quinlan**	▪ *died after 10 years in a coma*

In the last ten years research in many areas of biological sciences has produced spectacular achievements. The list above is a small selection of recent outcomes of such research (for none could be called 'discoveries') that have captured the imagination, interest and concern of the general community. What do they have in common?

All, in some way, owe their 'fame', if not their continued existence, to biological technology (or its inhibition in the two environmental cases). All have created community interest and sustained controversy about the legal, ethical and social consequences of the use of these technologies.

It is probably true to say that none of the scientific technologies themselves, nor even the scientific knowledge on which the technologies were based, are in the core biology curriculum of the great majority of secondary schools.

In other words, students are completing secondary school ignorant of recent developments that will undoubtedly shape their lives and poorly equipped to contribute to decisions that must be made and that may change the society in which they will live.

Should such developments and their possible consequences be included in school biology curricula? How much biological knowledge does one need in order to be able to understand the significance of the development and the nature of such a controversy?

DEFINING AN ISSUE

What is meant by an 'issue' in biology?

An issue is an important topic of discussion on which there are differing views, and considerable argument. An 'issue' in biology may be described as a development in a field of biology on which there are differing views about its application or possible consequences. This does not necessarily mean that all new biological developments are 'issues'. For example the cochlear implant (commonly called the 'bionic ear') has recently been developed and successfully implanted into several Australians with impaired hearing. No controversy has followed this announcement. In contrast the development of the artificial heart caused widespread and serious debate throughout the world. Why? What is the difference between these two developments that causes one to be accepted but the other to be so critically discussed?

Example 7.25: Two short episodes as case studies involving ethical decisions

School System: -
Approach: Succinct description of episodes involving ethical dilemmas for case study analysis
Source: Brumby, Margaret and Payne, V. "Teaching Ethical Aspects of Health Care" in Kelly, P.J. and Lewis, J.L. Education and Health (Science and Technology Education and Future Human Needs Volume 5). Oxford: Pergamon Press for the ICSU Press 1987 pp 195-198.

The Accident

One day a serious road accident occurs at a busy intersection. Several people are injured and are taken to hospital. Three are equally badly injured and need emergency care to save their lives. There is only one doctor on duty. Witnesses to the accident have given the following information about the three people:

Mr. A – the policeman on duty at the crossing;
Mrs. B – a mother with three young children;
Mr. C – a senior student at the nearby high school.

Who should the doctor treat first?

Jane's Birthday Party

The situation: Jane's birthday party.
The people involved:

George	A smoker since he was 12 years old, who is determined to get his friends to smoke. He has a part-time job and seems to be pretty well off.
Peter	A non-smoker. He likes sport and plays football for the school and a local club. He does not like the smell of smoke and thinks it will harm his wind. He likes to be one of the group.
Maria	Not sure yet about smoking although she has smoked many times and thinks it makes her look sophisticated. She likes to go along with the group.
Jane	A non-smoker. She does not like the smell of smoke and it makes her cough. She had a heart operation when she was a baby and thinks smoking could be bad for her.

The four are together and George pulls out the cigarettes. "Come on", he says, "grow up". He offers the cigarettes round.

Example 7.26: Legal foundations of bioethics

School System: *Canada: Province of British Columbia secondary school biology*
Approach: *Examples of national (Canadian) legislation and legal positions relating to bioethical issues. Resource material for biology teachers*
Source: *University of British Columbia Resources Biology 11 and 12 Summer Institute 1986 August 18-22. Vancouver: Province of British Columbia Ministry of Education Curriculum Development Branch 1986.*

1. The 1986 curriculum guide for Biology 11 and 12 provides for an optional unit of 5 hours on bioethics for grade 11 biology students.

2. In what some lawyers still regard as the most significant case criminal proceedings were brought by the State of Tennessee against one John Thomas Scopes for having the temerity to teach Darwinian theory. The proceedings began in 1925.(Scopes v. State,289, S.W. 363).

3. Section 2 of the Canadian Charter of Rights and Freedoms guarantees freedom of expression subject to the reasonable limits clause contained in Section 1 of the Charter. The application of the freedom of expression provisions of the Charter to classroom teaching was tested in the Courts in the cases of Keegstra v. Board of Education of the County of Lacombe, No. 14,(1983) 45 A.R. 348, and Regina v. Keegstra,(1984) 19 C.C.C.,(3d) 254. Ethics are defined as the science of morals or the moral principles that guide us. Bioethics is the application of the science to the field of biology.

4. At least one Canadian Judge has ruled that there is no right to abortion grounded in the Charter. (Morgentaler v. The Queen,(1975) 53 D.L.R.,(3d) 161). A fetus has been determined to be excluded from the protection of the Charter (Borowski v. The Attorney General of Canada,(1984) 1 W.W.R., 15), although a fetus once born has been able to recover damages for injuries, "en ventre sa mere", (Duval v. Seguin,(1973) 40 D.L.R.(3d) 666.)

5. Dr. Henry Morgentaler has been personally responsible for a number of the leading Canadian decisions concerning the abortion section of the Canadian Criminal Code (Section 251(4)) including the case of Regina v. Morgentaler,(1985) 14 C.C.C.,(3d) 258. British Columbia has also explored the abortion sections of the Criminal Code in the case of Carruthers and Whelton v. Langley, et al,(1986) 2 W.W.R., 459. Contraception is practiced by vast numbers of Canadians in one form or another. The teaching of sex education was considered an unacceptable teaching practice and one component of a just cause for the dismissal of a teacher in the Nova Scotia case of Bates v. Colchester-East Hants Amalgamated School Board,(1982) 53 N.S.R.,(2d) 269. In its most extreme form, contraception is practiced by way of sterilization. Ethical concerns relating to sterilization and contraception arise when it is proposed for infants or the mentally handicapped. (Re Eve,(1981) 115 D.L.R.,(3d) 283; Re Infant "K",(1985) 19 D.L.R., 4th 255).

6. The other side of the coin concerning contraception relates to artifically assisted conception and genetic counselling. The possibilities for such conception have extended dramatically. "The decision to marry and have children might be granted constitutional protection because they are considered deeply rooted in our tradition, and fundamental to our way of life." (Parker, J., in one of the Morgentaler cases) The question of property in an embryo as well as questions of inheritance and adultery have yet to be fully explored by the Courts when dealing with some types of artifically assisted conception.

7. A discussion of euthanasis requires the consideration of Sections 2 and 15 of the Charter. They also bring into play moral and religious convictions. (Re J.W. 25 R.F.L. (2d) 395; Regina v. Tutton and Tutton, (1985) 18 C.C.C. (3d) 328; The Attorney General of British Columbia v. Astaroff,(1983) 54 B.C.L.R. 309; the case of Karen Ann Quinlan, 355 A.2d 647(1976).)

8. Transplantation: at present it is possible to transplant almost any human organ, and work continues in efforts to accomplish the regeneration of nerve function and to explore the possibility of even brain transplants. Blood and organs are sold openly in the United States. The possibilities require moral, ethical and philosophical consideration.

9. Medical experimentation does have its restrictions. (Halushka v. The University of Saskatchewan, (1965) 52 W.W.R. 608).

10. Unless death is certain, the Courts will always favour action to preserve a life, no matter how disabled. (Superintendent of Family and Child Services v. R.D., et al, (1983) 42 B.C.L.R. 173).

11. The concept of a wrongful life has traditionally been rejected in Canada (Doiron v. Orr, (1978) 20 O.R. 71). The parents of unwanted children have however had some success in the recovery of damages (Cataford v. Moreau, (1978)114 D.L.R. (3d) 585).

12. While some of these subjects may be unsuitable for inclusion in the course curriculum for students in biology 11 and 12, the principles that they evoke are at the least transferable.

iii) Examples of Project and Test Questions

. Project. Discussion Questions on human fertility and reproduction.

1. In cases of infertility, should any action be taken to try to overcome the situation?
    (a) you shouldn't interfere with nature or the perceived will of God, should you?
    (b) it isn't necessary to have children, is it?
    (c) isn't the world overpopulated enough already?
2. If infertility treatment is desirable, who should be eligible for treatment or assistance?
    (a) married couples?
    (b) heterosexuals in a stable relationship?
    (c) a woman in a lesbian relationship using AID?
3. A recommendation made in the Warnock report is "any third party donating gametes for infertility treatment should be unknown to the couple before, during and after the treatment, equally the third party should not know the identity of the couple being helped." Do you agree?
4. A child conceived by AIH is legitimate, one conceived by AID is illegitimate. Is this fair?

5. Do you approve of AID? In what circumstances could it be particularly useful other than in cases where the husband is infertile? What arguments can you put forward against AID?

6. What are your views on surrogacy?
   - is it a good idea in general?
   - should it be subject to legal control?
   - should arranging agencies be permitted?

7. Should sex-selection tests be performed on embryos? Are there any circumstances when this is desirable?

8. Should human embryos be used for research?
   - what research was necessary to make IVF possible?
   - should any research be permitted?
   - if no, why not?
   - if yes, what safeguards should there be?
   - how should embryos be obtained for research purposes?
   - how long should embryos be allowed to be kept frozen?
   - up to how many days development should embryos be used for research?
   - is it permissible to use embryos for drug testing?

9. What future developments do you think there will be to help infertile people?

Note: AID = Artificial insemination by donor
AIH = Artificial insemination by husband
IVF = *In vitro* fertilization.

Source: Passmore, E.L. "Ethics and Social Responsibility in Science Teaching - An Exemplar 'Aspects of Human Reproduction'" Frazer, M.J. and Kornhauser, A. *Ethics and Social Responsibility in Science Education* (Science and Technology Education and Future Human Needs Volume 2). Oxford: Pergamon Press for ICSU Press 1986 pp 183-188.

. *Project*. *Analytical questions for case study analysis*.

Each student is to make an analytical study of at least one social issue which involves biological knowledge being applied to an aspect of human life, and over which there is significant community controversy. Some examples follow:

* producing human infants by *in vitro* fertilization;
* using genetic counselling in advising prospective parents;
* birth control to limit human populations;
* producing new species and varieties by recombinant-DNA technology;
* preserving natural areas or using them for resource development;
* the effects of smoking, alcohol or drugs of addiction;
* the use of laboratory animals in scientific research.

For each issue chosen, the student is to:

* identify the critical questions over which there is disagreement;

- find out - as completely as possible - the arguments used on both sides of the issues, using library references and other published information;
- participate in thorough reasoned debate with other students;
- present a written report which sets out the issues clearly, thoroughly and concisely.

Source: Brumby, Margaret "Teaching and Learning About Issues in Biology". Unesco New Trends in Biology Teaching Volume V. Paris: Unesco 1987 p 51.

. Project. Further discussion questions on bioethical issues.

- Should the stored sperm of people who have since died be used for artificial insemination by donor?

- Should money be spent on the arms race be diverted to famine relief in the Third World?

- Should native forests be destroyed for short term economic gain?

- Should it be possible for a commercial firm to patent a micro-organism which has been modified by biotechnology to possess characteristics of high commercial value?

Source: Meyer, G. Rex "Current Issues in Bioethics: An Educator's Response" Biology International Special Issue No 11 1986 pp 22-30.

. Test Questions

1. Birth Control is a very controversial subject. Write an essay on it bringing out its importance to individuals, its importance to nations, the dangers associated with it and the different moral viewpoints held on it.

Source: UK Examination "Science-in-Society Project" cited in Kelly, P.J. and Lewis, J.L. Education and Health (Science and Technology Education and Future Human Needs Volume 5). Oxford: Pergamon Press for the ICSU Press 1987 p 267.

2. A recent development in genetic engineering to attract attention in the press was the successful transplant of a rabbit gene into monkey cells by Berg, Mulligan and Howard at Stanford University. Commenting on this achievement, one scientist stated that it should be possible to develop the technique so that it could be used to replace defective or missing genes, to suppress the expression of genes which are harmful and to introduce genes into animals and plants which would make them better suited to serve mankind.

Consider a large group of enthusiastic scientists experimenting in this way with gene transplantation.

(a) Carefully describe two *specific* dangers from these experiments which they should bear in mind.

(b) What should the scientists do to minimize the risks arising from the breeding of new strains of animals and plants?

(KNOWLEDGE 4 marks, ENQUIRY SKILLS 9 marks, ATTITUDES 2 marks)

3.

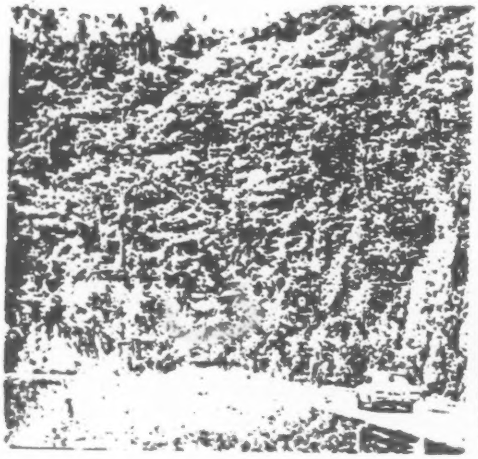


Figure 4

An area that was earmarked as a source of rock for road building.

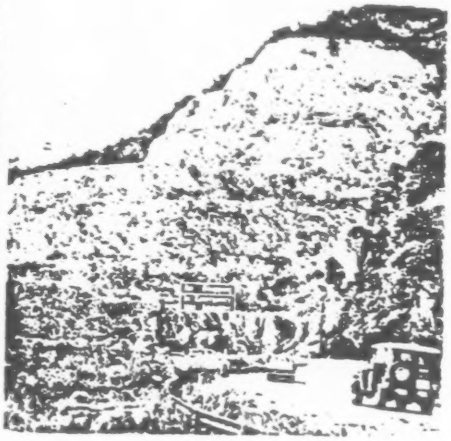


Figure 5

The area in Figure 4 shortly after the excavators moved in.

(a) The construction firm promises that the hillside will be replanted to restore its beauty. Considering the fact that in the excavation top-soil was removed and bare rock exposed, discuss what measures the firm could take to ensure that the promise can be kept.

(b) The hillside rises above a city. A group opposed to the excavation argues that flooding will occur in the city and also that the water supply to the city will be reduced.
How could excavation contribute to these problems?

(c) The Minister of Works states that "you can't make a cake without breaking eggs", and points out that the type of rock on the hillside is very suitable for making roads.
Write a paragraph in which you discuss the difficulties the Minister must have faced in taking the decision to excavate.

(KNOWLEDGE 2 marks, ENQUIRY SKILLS 5 marks, ATTITUDES 3 marks)

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Source of test questions 2-3 Caribbean Examination Council Past Papers Integrated Science General Proficiency. Kingston: Jamaica Publishing House 1983 pp 6 and 15.

4. A baker was found to have put sterilized sawdust in bread to increase bulk and reduce costs. He was fined by the local health authorities.

   i) If the additive is harmless why should the baker have been fined?
   ii) What laws should there be to control putting additives in food?

[Essay of two pages]

Source of test question 4: Suggestion by author.

7.7 Use of Leisure

i) Rationale

As the well known biology educator Professor A.N. Rao has pointed out "one aspect ... that has so far received little attention by the school science teacher is the preparation of pupils for the effective use of leisure time" (13).

In quantitative terms leisure is the time left over after completing work for maintaining life. Leisure hours may be spent in relaxation, sport, engaging in hobbies or in creative activities such as writing, art, politics or religion. In a productive and healthy society the use of leisure should contribute to the mental and physical wellbeing of the individual and to a positive life style enjoyed by society as a whole.

School biology courses can help to meet this societal need by exploring those aspects of leisure which have a basis in biology, or which have links with biology. In the first place leisure activities for most people include some physical activity such as sport, outdoor pursuits such as fishing, hunting, bushwalking or swimming and physically active hobbies such as gardening. The biological basis of exercise and the importance of exercise and good nutrition in maintaining good health can be related to these leisure activities. In addition biological hazards such as stress, over exposure to cancer inducing sunlight and hyperactivity in sport or other forms of physical activity can be dealt with.

Other aspects that can be considered include the wide use of more passive forms of leisure activity such as watching television, reading or just physical relaxation. These types of leisure activities can be positive influences on personal development if an appropriate balance is maintained between active and more passive leisure activities and between the types and quality of individual experiences. In many cases, too, biology teachers can encourage the use of leisure to build up a general knowledge of biology and its applications.

Biology teachers can also draw attention to community facilities and resources for a positive use of leisure. These can include national parks, botanical gardens, zoos, museums, libraries and organizations such as hobby clubs, sports groups, health clubs and so on.

Another aspect of leisure that can be treated within a programme of school biology is an individual's responsibilities in undertaking leisure activities. These include respect for and careful use of the natural environment, the guardianship of other species, sensitivity to the needs and interests of others, safety aspects and financial considerations.

In many societies today leisure time is abused, especially by adolescents. Leisure time is used by some for anti-social behaviours such as petty crime, drug abuse, destruction of property and so on. All teachers need to encourage young people to plan use of their leisure time wisely but biology teachers have an especially important role to play in developing a sound understanding of the principles involved and in fostering positive attitudes.

ii) Examples of Content

Example 7:27: Vacation activities project

School System: *Republic of South Africa - Natal secondary schools*
Approach: *A report to teachers of the Vacation Activities Natal (VAN) Project*
Source: *Kirkness, P.R. "Vacation Activities" in Natal Education Department Bulletin 15 Educational Field Activities. Durban: Natal Education Department undated pp 8-10.*

Vacation Activities

One of the surest ways of combating juvenile delinquency is to ensure that teenagers are usefully and happily occupied during school holidays. For this reason the organisation known as V.A.N. (Vacation Activities Natal / Vakansie Aktiwiteite Natal) was established.

The Central Committee of V.A.N. has representatives of the Natal Education Department, the Teachers' Societies, the Department of National Education, the N.E.A.A. and certain service and youth organisations. Sub-committees of V.A.N. operate in various geographical areas and are responsible for the planning and running of holiday programmes in those areas. To date these activities have been limited to the Durban area only. The four sub-committees operate in the following areas: Durban North, Central Durban, Umbilo and the Bluff. Generally the holiday courses have been run by teachers. In fact it is only where teachers have become involved in these projects that the courses have been successful.

EDUCATION FOR LIVING

The duration of a V.A.N. course has been 5 days. The courses are open to pupils of Natal High and Secondary Schools. As there are no boarding facilities only pupils living within daily travelling range of the venue are able to attend. V.A.N. has as its main aim the equipping of children to be able to use their leisure time beneficially and in a manner which is acceptable within the framework of our cultural background. At these courses teenagers are introduced to various hobbies, sporting and cultural activities The activities are explained and demonstrated and wherever possible the pupils are encouraged to take part in the activity.

SURVIVAL

Another important facet of V.A.N. courses is the instruction in self-defence, survival and youth-preparedness. Pupils are instructed (by qualified instructors) in karate, judo, first aid and survival. During a recent holiday course both boys and girls spent a day and a night in the open. Although tents were available in case of emergency the children slept under the stars. They were shown how to set traps to catch animals and instructed on how to live off the land. In particular they were taught how to obtain sufficient drinking water for survival in dry areas. There is, of course, an element of danger in such undertakings but the organisers take every possible precaution to prevent serious mishaps while at the same time retaining the element of adventure.

Some activities offered at courses are detailed below:

Sport

Tennis, swimming, under-water swimming, diving, athletics and rugby have been successfully offered at various courses. In all cases competent instructors have demonstrated the various techniques.

Cultural Activities

Courses in folk-dancing, ballroom dancing, art, music appreciation and modelling have been made available.

Hobbies and Crafts

A wide range of hobbies and crafts has been arranged. These include stamp-collecting, embroidery, woodwork, metalwork, mechanics, leatherwork and make-up.

ADVENTURE COURSE NEEDED

A need exists for more adventure-type courses but more facilities are required. In particular a piece of land large enough and with a diverse vegetation and topography would have to be available sufficiently close to the larger centres to reduce transport costs. If such a piece of land were to be acquired it would be possible to run courses continuously during the holiday periods. The pupils could either be transported to the venue daily or could be housed at the site at low cost.

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PLEA FOR EXPANSION

At present only a small percentage of the pupils is being catered for annually. No provision is made for Primary School pupils. In this age of working mothers and broken homes, it is vital that children be gainfully occupied during holidays. Many city children are sent to hostels in country areas because of the lack of control at home. Any good that is done at these schools is soon undone when they return to the cities during school holidays. Holiday courses offered are of a high standard but far too few pupils attend them.

The holiday activity programme must be broadened to cater for a much larger number of pupils. To do so will need greater expenditure but an investment in the youth of one's country is surely the soundest investment that taxpayers can make.

Example 7.28: Organization of school camp

School System: Canada: British Columbia secondary schools
Approach: Notes for teachers on how to integrate academic, recreational and social living skills in a school camp
Source: Gornall, Fred A. "Field Trips and School Camps - Developments in British Columbia" in Meyer, G. Rex and Rao, A.N. Teaching Science Out-of-School with Special Reference to Biology. Singapore: IUBS-CBE and the Asian Network for Biological Sciences 1984 pp 83-38.

School camps

These are usually operated on a school schedule where traditional subjects must still be identifiable as mathematics, language arts, spelling, art and so on. – how sad! – The programme involves three phases, an academic phases embracing the subjects mentioned above, recreation phase and the social living phase. The academic phase is usually scheduled from 9.00 am until 3.00 pm recreation from 4.00 until 6.00 pm and social living in the remaining hours.

In a recent survey on the likes and dislikes of students who had participated in school camps, the strongest negative reaction was "standing around waiting for something to happen". A follow-up study showed that this was indeed true. Perhaps there is a relationship between the academic-recreation-social structure which makes time wasting inevitable. Let us turn again to a positive approach. Here are suggestions for more efficient use of both time and the site:

1. Integrate the three phases mentioned previously. Why should every person be doing the same thing at the same time? This makes sense in the use of equipment and space as I have yet to see the centre or classroom that has sufficient equipment to accommodate all students at the same time. Spread "academics" throughout the day and integrate with recreational pursuits also spread throughout the day.

2. Use the evening period, for example, for studies which can seldom if ever be done in most classrooms, astronomy, or just plain star-gazing. Sunset, sunrise and night sounds also fit this pattern. Here also is an excellent opportunity to record weather data not normally observed. The moon of course is much more readily observed at this time.

3. Most camps are inundated with signs which stress the negative. "Do not run", 'No swimming", "Do not light fires' , No cutting of trees", "Keep off the grass", etc. Let us replace these if they are truly necessary with positive signs. "No running" becomes "Please walk in a quiet respectful manner".

4. Set aside places where the normally forbidden activities may be carried out. "The Use of Axes, Knives and Saws is Allowed only in this Area". Set aside an area where one tree, one stump and one log may be hacked, cut or otherwise mutilated. Similarly an area should be set aside for fire lighting and yet another area where digging or planting may be carried out.

5. Arrange for camp staff to share the load, spell one another off or work in shifts. In most camps all staff work 16 hours each day from Monday to Friday as long as classes are present. This should not be. Shifts of not more than eight hours are sensible and practical. Additional supervision will be necessary. We have found part-time volunteer supervisors readily available. Some sources for these volunteers are: older students in special community activity programmes as part of their secondary school courses; parents; pensioners and other retirees; workers on vacation; injured persons under recuperation; trade-offs with other teachers; and on weekends ordinary interested citizens. The supervision ratios recommended by national youth organizations across Canda are: 1-10 for adults, 1-8 for older children and 1-6 for young children.

6. Help out the cook and at the same time give your programme more flexibility. Most camp programmes are organized around the cook's schedule. A compromise can be worked out to reduce the cook's work. Set up a buffet lunch counter where individual or groups of students can come to lunch at their convenience and make their own lunches. We have also effectively organized breakfast on this same scheme. The evening meal is retained as a family gathering. The use of students in the kitchen may be necessary to trim the financial budget but it is an inefficient use of the student's time from the educational aspect.

7. Arrange grouping on strenuous activities so that the more robust students have a greater challenge. This could involve travelling a greater distance to reach a designated destination, or travel a tougher route or simply stagger the times of departure so that the stronger group leaves last and must travel faster to arrive on time.

8. Better preparation of teachers for this type of activity is essential. Instruction in logistical and programme planning must be incorporated into programmes of teacher education. In-service training programmes must be provided to aid those teachers who require or desire additional help and information. In British Columbia we have much help with this from non government sources. The Canadian Forestry Association frequently provides weekend workshops for teachers sometimes with children also involved. Private companies arrange for week-long workshops and visits to forest operations and mining activities at no charge to the teachers. Teachers are released from class during school time for these sessions. A second forestry organization, the Festival of Forestry, arranges tours of forest operations for combined groups of forestry and education students from the local universities.

9. Evaluation instruments must be developed to show the worth of out-of-classroom experiences.

Example 7.29: Skin care in outdoor leisure activity

School System: Australia - secondary school science

Approach: Advice to students on protecting their skin during recreational activities. Skin cancers are a major health problem throughout Australia.

Source: Anti-Cancer Council of Australia "Skin Wisdom" in Australian Science Teachers Association Australian Science in Schools Week Resource Book. Melbourne: ASTA 1988 p 26.

SKIN WISDOM

The following information was provided by the Anti-Cancer Council of Victoria.

SUN BURN - SUN SMART

Have a great time this summer and protect yourself against the harmful effects of the sun.

Just follow these simple tips and have a healthy summer.

Why you should protect your skin

- Two out of three Australians will develop skin cancer due to too much sun when they are young.
- You'll reduce your risk of sun damage and skin cancer.
- Years of sunbaking will thicken your skin and make it look like leather.
- You won't suffer the painful effects of sunburn.

How to protect your skin

- Shade your skin between 11am and 3pm. That's the UV radiation danger zone when the sun is strogest.
- When you're outside - tree-shade, hat-shade and shirt-shade will save your skin.
- Use a 15+ broad spectrum sunscreen. Our sun is so strong that you will tan through it but sunscreen will help protect against skin damage.

Treat the skin with healthy respect and you'll have a fantastic time this summer. That's being sun smart.

THINKING ABOUT SKIN

Prepare a class talk on one of the following skin subjects.

- Animals that shed their skins
- Camouflage
- Natural skin coverings

Make a poster, chart or board game on one of the following subjects.

- Protecting the skin from sun, snow, wind, fire.
- Cat's claws

Example 7.30: Survival kit for wilderness leisure activities

School System: *Canada. British Columbia science secondary schools*

Approach: *Instructions for pupils on making and maintaining a survival kit for use on hunting or expeditions in relatively remote areas*

Source: *Province of British Columbia Ministry of the Environment "Conservation and Outdoor Recreation Education Program Instructors Manual" 1983 in Instructors Manual 1983. In University of British Columbia Biology 11 and 12 Summer Institute 1986 Resources. Vancouver: Province of British Columbia Ministry of Education Curriculum Development Branch pp 10-11.*

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LESSON: 5. MAKE UP A SURVIVAL KIT

APPROXIMATE TIME: 20 minutes

AIDS: OVERHEAD TRANSPARENCY, OF HANDOUT OF SURVIVAL & FIRST AID CHECKLIST

INSTRUCTOR NOTES:

A minimal amount of materials used as a survival kit should be kept with you at all times. The question to ask yourself is: "Could I survive with what is in my pack if I broke a leg in the specific area I'm going to hunt?" Each individual and each situation will have different requirements for a survival kit. For example, am I alone or with a companion? What time of year is it?

Survival Kit Checklist:

In pocket:

- Bandana
- Candle
- Compass
- Fire starter - 000 steel wool, cotton balls
- High energy food
- Map
- Notebook and pencil
- Nylon cord - 7 m
- Plastic bag or sheet
- Pocket knife or belt knife
- Pocket size first aid
- Signal - mirror
- Trail food
- Toilet tissue
- Visible supply butane lighter
- Waterproof matches
- Whistle

Separate container:

- Aluminum foil (heavy duty)
- Chocolate
- Coffee
- Curved needle
- Dental floss
- Emergency blankets
- Fishing Line and Hooks etc.
- Flares
- Flash light, candle or chemical light
- Ground to Air Signal Card
- Halazone tablets
- Knife
- Medium compress bandage
- Metal container containing:
- Mirror
- Plastic bags
- Salt
- Several large bandaids
- Small bandaids
- Small compress bandage
- Snare wire - 3 m
- Soup - dehydrated
- Spoon
- Survival saw
- 222
- Insect repellant
- Tea
- Wire

LESSON PLAN

INSTRUCTIONAL OBJECTIVE:

The student will gather materials and equipment to make an emergency survival kit to meet their personal needs.

TEST PROCEDURES OR REVIEW:

Student will compile a survival kit and show it to the instructor. Allow sufficient time for student to compile the kit. Assign as homework to be submitted to the instructor.

STANDARD:

Kit must include all of the required articles.

THE INSTRUCTOR WILL:

Any trip outdoors is a potential emergency situation. "It couldn't happen to me" is a poor substitute for an emergency shelter when you are lost, injured or caught in a storm.

A good survival kit should be appropriate to the area that is hunted. Select and adapt the kit described below to meet the needs of the individual.

Show and list required articles.

Assign the making of a survival kit for homework.

THE STUDENT WILL:

a) Several students will show their kits to the rest of the class and describe what each item is and how it will be used in a specific situation.
b) All students will turn in a survival kit to be checked by the instructor.

iii) Examples of Project and Test Questions

The following questions suggested by author.

. Project. Planning holidays. Plan what you will be doing the next long summer school holidays to make the holidays most interesting and enjoyable. You might like to think about the following:

a) Will you play sport? Which? How often?
b) How much of your time will you spend being physically active in other ways? What will you do?
c) How much television will you watch each day? What types of programmes will you select?
d) Do you plan to work on your hobbies? If so, what will you do and how much of your time will you give to this?
e) Will you visit any places or go to see friends? Make a rough plan of where you will go and what you will do.
f) Do you plan to do any reading? What will you read? How much time might you give to this?
g) Will you do anythng to earn some pocket money? If so what will you do?
h) What else might you do during the holidays to get the most fun out of them?
i) Look back over your plans and see to what extent, if any, they have been influenced by your study of biology. Do you want to make any changes?

- Project. Interesting leisure. A knowledge of biology can often make your leisure and recreational activities much more interesting. Choose any four of the following leisure activities and for each write two or three sentences about how a knowledge of biology could make them more worthwhile for you.

  Swimming
  Stamp collecting
  Trekking or bushwalking
  Drawing or painting
  Reading
  Writing to friends
  Watching television
  Gardening
  Playing your favourite sport
  Picnicing
  Keeping a diary
  Playing computer games

- Project. Sport as leisure. What is your favourite sport or outdoor recreation activity? How could knowing about the following topics improve your sporting or recreational skill? Write only a few sentences on each topic.

  How muscles work
  Breathing and respiration
  The brain and nerves
  Food and nutrition
  Sense organs

- Test Questions

  1. Bob spends most of his leisure time watching television and reading. Mary on the other hand usually spends her free time during the day playing sport or working in the garden. She limits TV and reading to selected evenings. Mary is generally much healthier than Bob and she rarely gets ill. Bob often has colds and is not very strong.

     Briefly answer the following questions.

     a. What does exercise do to the body to make Mary stronger than Bob?
     b. Is watching television bad for you? Explain your answer.
     c. Apart from exercise, name two things you should do to keep fit and healthy.

  2. Write a short essay on using the natural environment for leisure activities. As part of your essay comment briefly on your responsibilities when using the natural environment for recreation.

3. Choose one of the following sports.
   - Soccer
   - Golf
   - Tennis
   - Netball
   - Basketball

   Suppose you were a coach. List five things you could say to the players to help them improve their game. Make use of your knowledge of biology in giving the advice.

4. Suppose you were the chairperson of a committee managing a large national park. What policies would you suggest to ensure that an appropriate balance is maintained between the use of the park for leisure activities and its role in conserving plants and animals?

5. Some people claim that leisure time should be planned. Others say that if you plan your leisure it becomes too much like work. What do you think? Justify your answer [write about two pages].

6. Can a knowledge of biology make it easier to use leisure time wisely? Explain your point of view [two pages].

7.8 Equal Opportunity Issues

i) Rationale

Women's liberation, the combating of sexism in society at large and the provision of equal opportunity for women in the workforce, have their origins in biology and their study and review should be an important part of any socially oriented school biology programme. Certainly senior biology students should understand that the liberation of women has been possible only because of a biological advance - namely the advent of fail-safe contraceptive methods which have freed women from the inevitable slavery of cyclical child bearing.

Programmes focusing on this area of concern should perhaps begin with purely biological issues such as genetic sex determination, the inheritance of sex linked characters and the biological differences between males and females, especially at puberty and sexual maturity. This, indeed, is usually as far as most classical biology programmes go. In more socially oriented programmes social applications and implications need to be examined.

One of the areas that needs to be explored is the issue of sex stereotyping (14). Its origins in cultural evolution and the processes of learning which result in sex stereotyping make a fascinating case study of behaviour. Certain aspects of sex stereotyping are relatively straight forward as research problems which can be undertaken by school age groups.

Discussion of sexism in society is an especially important aspect of this topic. Biological science based careers can provide an interesting series of case studies about the proportion of men and women entering these careers; the typical career paths of men and women; the motivation of each sex to enter that particular career in the first place and the relative recognition extended to men and to women working in these fields by their peers and by society in general.

In summary an important role for a socially conscious biology teacher is to combat sexism by making its characteristics and origins overt; by reducing bias and prejudice through rational problem solving involving specific episodes and cases, and by providing positive role models of women in science.

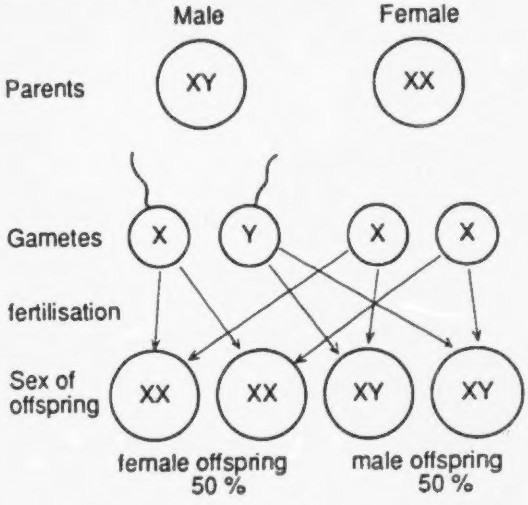
ii) Examples of Content

Example 7.31: Sex determination

School System: Australia - senior secondary school biology
Approach: Clear diagrammatic summary of the genetical basis of sex determination
Source: Hill, Jennifer; Meyer, G. Rex; Cohen, David, and McDonnell, Kevin *Excel HSC Biology**. Sydney: Pascal Press 1990 p 88.*

Sex determination

Sex chromosomes determine the sex of the organism. Sex chromosomes like all other chromosomes separate at meiosis.



Example 7.32: Biological and psychological changes at puberty and sexual maturity

School System: -
Approach: *Tabular list of events as a resource framework for teachers*
Source: *Burnham, Teresinha Human Development and Evolution (Science and Technology Education Document Series No 15). Unesco: Paris 1985 pp 58-59.*

Development in puberty and adolescence

Sexual maturation

Nervous and regulatory systems integration
- Co-ordination of hormonal production
  - . hypothalamus: control: posterior pituitary gland: adrenal medulla:
  - . anterior pituitary gland: stimulation:
    - . adrenal cortex
    - . ovary
    - . testes
    - . thyroid gland
  - . adrenal cortex, ovary/ testes, thyroid: suppression:
    - . anterior pituitary gland hormones.

Physical growth
- adrenal cortex:
  - . androgen
- thyroid:
  - . thyroxin
- pituitary:
  - . growth hormone

Sexual maturation
- gonads development
  - . anterior pituitary gland: gonadotrophis (FSH and LH):
    - . ovary/testes maturation
- production of sex hormones
  - . ovaries: estrogen; progesterone.
  - . testes: testosterone.
  - . adrenal cortex androgens.

Psycho-social maturation and environmental influences

Emotional changes related to
- body changes
- sexual maturity
  - . adjustment to personal
  - . sexuality
  - . sexual attraction
- links to peer groups
  - . common interests
- family structure
  - . breaking away from the family
  - . personal independence
- society structure
  - . need of integration: small communities:
    - . role in the family pattern of activity
    - . integration in the community: rites of passage
    - . developed societies
    - . lack of definite role in the family
    - . lack of society support for engagement in productive roles
    - . establishment of a youth sub-culture.

Example 7.33: Sex education programme

School System: Hong Kong junior and senior secondary schools
Approach: Curriculum (Syllabus) in sex education
Source: Education Department Hong Kong Guidelines on Sex Education in Secondary Schools. Hong Kong: Education Department Curriculum Development Committee 1986 pp 13-16.

A. Junior Secondary

(1) UNDERSTANDING OURSELVES

- a. Physical Changes at Puberty
  - i. The onset of the adolescent growth spurt
  - ii. Patterns of development and individual differences
  - iii. Development of secondary sexual characteristics
  - iv. Emotional adjustment related to physical changes
- b. Coping with Sexual Tensions - Some Positive Means
- c. Human Reproductive Systems, Pregnancy and Birth
  - i. Male and female reproductive systems
  - ii. Menstruation and nocturnal emission
  - iii. Conception, pregnancy and birth
- d. Mental and Emotional Behaviour of Individuals
  - i. Factors influencing one's emotions
  - ii. Developing emotional maturity
- e. Self-Image
  - i. Sex role identity
  - ii. Self-awareness and self-understanding
  - iii. Need for independence,

B. Senior Secondary

(1) UNDERSTANDING OURSELVES

- a. Self-Concept
  - i. Self-awareness and self-acceptance
  - ii. Importance of establishing an individual value standard
- b. Towards Emotional Maturity
  - i. Understanding emotions
  - ii. Developing emotional maturity
  - iii. Characteristics of mental and emotional health
- c. Personality Development - Developing a Healthy Personality

(2) UNDERSTANDING OF AND RELATIONSHIPS WITH MEMBERS OF THE OPPOSITE SEX

- a. Human Reproductive Process
  - i. Male and female reproductive systems
  - ii. From conception to birth
- b. Social and Emotional Problems Related to Sex
  - i. Emotional problems arising from adjustment to physical changes
  - ii. Social behaviour and relationship with the

social acceptance and identity

- f. Personality Development
  - i. Factors affecting the development of personality
  - ii. Improving one's personality

(2) FAMILY LIFE

- a. Family Living: Roles and Values
  - i. Purposes and functions of the family
  - ii. Roles and responsibilities of different members of the family
- b. Family Relationships - Between Generations
- c. Relationship with Brothers and Sisters

(3) GETTING ALONG WITH OTHERS

- a. Making Friends
  - i. Need for making friends
  - ii. Value of friendship
- b. Peer Group Influence
  - i. Need for peer group acceptance
  - ii. Choice between independence and conformity with others
- c. Boy-Girl Relationship
  - i. Behaviour in a mixed group
  - ii. Developing social maturity in relationship with members of the opposite sex
- d. Differences between Love and Infatuation
  - i. Meaning of love
  - ii. Meaning of infatuation
  - iii. Dating behaviour

opposite sex

  - iii. Sexual exploitation
- c. Love and Infatuation
  - i. Meaning of love
  - ii. Meaning of infatuation
  - iii. Differences between love and infatuation
- d. Dating and Courtship
  - i. Purposes of dating
  - ii. Purposes of courtship
  - iii. Attitudes towards dating and courtship
- e. Responsible Sexual Attitudes and Values
  - i. Respecting others' values and feelings
  - ii. Setting limits in boy-girl relationship
  - iii. Considering the consequences of premarital sexual relationship
- f. Preparation for Marriage
  - i. Choice between marriage and remaining single
  - ii. Choosing a life partner
  - iii. Responsibilities in marriage.
- g. Sexually-Transmitted Diseases
  - i. Types of venereal diseases
  - ii. Causes of venereal diseases
- h. Some Problems Related to Sex
  - i. Sexual offence
  - ii. Pornography

(3) FAMILY LIFE

- a. Nature and Functions of the Family
  - i. Nature of the family
  - ii. Functions of the family
  - iii. Problems in family relationship
- b. Family Planning
  - i. Factors to consider in family planning
  - ii. Methods of birth control
- c. Preparation for Parenthood

  - i. Child-bearing as a choice
  - ii. Factors to consider before becoming parents
  - iii. Qualities of 'ideal' parents
- d. Abortion

(4) INTERPERSONAL RELATIONS

- a. Meaning and Importance of Effective Communication between
  - i. Spouses
  - ii. Parents and children
  - iii. Friends of the same and opposite sexes
- b. Positive Values towards Interpersonal Relationships
  - i. Establishing a positive self-image and an individual value system
  - ii. Developing appreciation for and understanding of people with different values
  - iii. Awareness of others' needs and feelings
  - iv. Understanding love as a basic component in marriage and family life.
  - v. Making responsible decisions
- c. Equality of Sexes
  - i. Sexual stereotyping
  - ii. Women's liberation

(5) VALUES CLARIFICATION ON SEX ISSUES

- a. How to Establish a Positive Value System
- b. Values Clarification on Some Controversial Sex Issues
- c. Willingness to Accept Counselling and Advice

Example 7.34: Inter sex relationships and communication

School System: *Republic of South Africa. Natal secondary schools*

Approach: *Suggested content and activities for a unit on inter sex relationships with considerable focus on sex stereotyping*

Source: *Education Department Natal Family Life Education (Bulletin No 45). Durban: Natal Education Department 1988 pp 137-139.*

INTER SEX RELATIONSHIPS AND COMMUNICATION

OBJECTIVES

To help pupils to feel comfortable and confident in relating to the opposite sex in socially acceptable ways.

To promote mutual understanding and communication between the sexes.

To promote mutual respect and appreciation.

CONTENT	ACTIVITIES
1. Examine changing and current male/female roles.	Small groups/or pair projects on historical differences e.g. 1820 Settlers male/female roles; different communities e.g. Indian, Coloured, Zulu rural, urban male/female roles; general discussion.
2. Examination of personal sex role identity.	Personal interest/activity collage by each pupil, depicting how he sees himself.
3. Idealistic vs realistic sexual personality characteristics	Personal chart : my ideal self now/in the future vs my real self now.
4. Do I like myself? Am I different?	(a) What I like/do not like. (b) What I would like to change. (c) What I can change.
5. Socially desirable male/female characteristics in class, teenage society, adult society. Discussion of androgeny.	Activity in pairs - chosen friends work together.
6. Likenesses and differences in interests/characteristics/attitudes between girls and boys.	Pairs e.g. a girl and a boy compare lists : follow with report back.
7. Friendship skills : What makes good friendships.	Class discussion
8. Differences and similarities between same sex and other sex friendships (stress understanding, empathy, common interests, listening skills, humour etc.	Exercise Paragraph on "What is sex-appeal?" "What I took for in a boy/girl friend."

9. Emerging sexuality. Where do you make friends with opposite sex to gain confidence? Where would you like to meet?	Personal preference - pin strips with preferences on notice board : arrange into similarity zones.
10. Friendship skills : How to build bridges	5 sensible questions that might lead to friendship. Put them to someone you don't know well. Mend one "broken friendship bridge" outside the classroom. Report back. Class arranges and raises money for film outing. Draw from hat for partner. Exercise : How he/she can make the outing enjoyable I.e. working at making it fun. Organise a braai. Draw straws for "partner". Braai for each other. Discover 2 genuine points of interest during the evening.
11. Do you need another sex friend? Why?	Anonymous accounts of peer pressure placed on hat and read out OR
Peer pressure in other sex friendships.	Write a letter to Agony Ann.
12. Common embarrassments in other sex friendships. Dating. Current social etiquette. Value of etiquette? (manners)	Personal anecdotes from class, parents, friends, family etc. Reader's Digest - "Was my Face Red?" Class sharing: role play - by pairs. Contributions by class to discussion.
13. Dangers in other sex friendships, sexual, social, practical.	Parent's worries classified under justified/unjustified. Pupils' worries.
14. Broken relationships. How to cope with rejection.	
15. Importance of body image, clothing in other sex relationships. What is "sexy" dressing? What is "cool"? Misleading superficialities.	Show extracts from "Revenge of the Nerds" or "Elephant Man". Follow with class discussion. Dress acquiescent, well balanced boy and girl in way out gear. Discuss : Does this reveal their inner qualities. How does the way we dress express personality? Does it cover inadequacy - why make-up?
16. Distinction between passing attraction, infatuation, puppy love, enduring love, platonic love.	Discuss extracts of episodes from "Dallas", soapies from TV to illustrate the difference.
17. Should teenage relationships last? Qualities of lasting adult relationships. Readiness for different stages of love. Sex and love LEADING TO	
18. Sexuality education Biological facts Abuse	

Example 7.35: Women in science

School System: *World wide but with special reference to Scandinavia*
Approach: *Background reading for teachers on equal opportunity problems for women in science - extract from an article*
Source: *Sjøberg, S. "Girls Need Science - Science Needs Girls" in Frazer, M.J. and Kornhauser, A. Ethics and Social Responsibility in Science Education (Science and Technology Education and Future Human Needs Volume 2). Oxford: Pergamon Press for the ICSU Press 1986 pp 231-238.*

The problem

The problem can be stated very simply: girls and women are totally under-represented in science and technology. This means that their voices are not being heard when important decisions are being taken — decisions that effect both the individual in daily life, society at large, and relationships between nations. Access to science means access to power, and women in general do not have this access. If there are particular concerns of women, this means that these are likely to be neglected when decisions are made.

Although the statistics on the participation of women in science and technology show large and interesting variations from nation to nation, the overall picture is the same. It can be seen as a reflection of the general picture. Women have less access to education than men. (UNESCO estimates that on a world basis, 33% of all women are illiterate, compared with "only" 23% of men.) But this general trend is more accentuated in science and technology than in other fields of study. In a paper prepared for UNESCO in connection with the Women World Conference in Nairobi, J. Harding has collected statistics on women's participation in science-related fields. The data cover all major regions of the world, and they are subdivided into fields of study and level. The general picture is universal and well known: female participation is low everywhere, but lowest in the "hard" and applied parts of science and technology, and it is decreasing at higher levels in the hierarchy (Harding, 1985).

It is a paradox that the explosion of female participation in higher education that has taken place in many countries, has resulted in a high female participation in occupations that study and understand society, while the occupations that shape and change society are still nearly totally dominated by men. This happens to be the case in Scandinavia, where women's participation in university education today is about 50%, but where their career choice still is very traditional. Many years of good and hard work from women's organizations have not led to many more women in scientific decision-taking processes. On the contrary, we often see a deliberate rejection of science and technology, which is seen as male-dominated and as a threat to human values.

The lack of female participation in science and technology is seen as a problem, both by international bodies and by many countries, although the underlying reasons for this interest vary widely: some see it in connection with democratic ideas concerning the right to participate in shaping the future society, while others see women as a new and interesting source of labour. It is high time that we began to see the untapped pool of the highly gifted girls. But regardless of differences in motivation, there is an international interest to try to attract more women to science and technology, and this is reflected in the official educational policies of many countries, as well as of international bodies like UNESCO.

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This growing concern for women in science has resulted in research programmes to study underlying causes, as well as action-oriented programmes to change the current situation. Three international conferences on Girls And Science And Technology ("GASAT-conferences") have been arranged, and the fourth one is being planned. The contributions to these conferences are published, and they shed light on all the different aspects of the problems (GASAT, 1981, 1983, 1985).

A spectrum of causes

The causes for the present situation are many, and their relative importance varies from one educational and societal context to another. The range of (complementary) explanations frequently put forward are mentioned below.

Some mechanisms are general, not directly connected to science. These operate (in different forms) in all societies, and are deeply embedded in the social systems.

Sex-stereotyping takes place from birth in any society, although its actual content may vary. Girls and boys are treated differently, they get different toys, they are subject to different (self-fulfilling) expectations, they get different experiences, develop different abilities, interests, self-images, etc. Most often, the stereotypes are supported ideologically with ideas about what is "natural" for the two sexes. Political ideologies, as well as religion, play an important role here, and often pseudo-scientific arguments are used to support the status quo.

In grading and judging the quality of pupils' work, one has also identified differences in favour of boys, a reflection of the different expectations teachers have of the two sexes. (For documentation of this and other assertions, see the GASAT publications.)

Also counselling and career advice have been shown to be strongly influenced by the general sex-stereotypes that operate in society.

Textbooks and curricula have also been analysed from the perspective of possible sex-bias. The results are presented in the GASAT reports and in some comparative studies undertaken by UNESCO (UNESCO, 1982–1984). The criticisms raised against the textbooks vary in depth:

1. Women are under represented in science texts. Simple counting shows this very clearly. Recent counting done in our own Norwegian project "Girls and Physics" (Lie and Sjøberg, 1984) show a 97%–93% distribution in favour of men. Many of the men are, however, historical persons. One can hardly try to change the sex of Newton or Einstein. But there are "forgotten" women in the history of science, who have not been given their proper place in the textbooks. More research has to be done in this area, very much as research is throwing light on the forgotten women in history, arts, etc.

2. Girls and women do not appear often in science textbooks, and when they are depicted, text and pictures support the stereotyped image of the female sex: passive or posing, traditional and confined to only traditional roles or activities. The textbook image is often more traditional than those found in society itself.

3. The concrete examples and illustrations used by authors are often taken from daily experiences and interests of boys. We know that reference to well-known examples are important for many reasons: it is easier to make abstractions when you can go from the concrete to the abstract, but then the textbook must build on experiences that do not favour one particular group of pupils. We also know that it is difficult to maintain interest in a subject which does not build upon, or appeal to the concerns of a pupil's daily life. With most of the current textbooks, the girls suffer from this.

4. Curricula and textbooks directly and indirectly convey a picture of what science is really all about. This is done by selection of course material; certain topics are included, other topics are not included. The particular context in which science is presented is also important. (Lack of context is indeed also a particular context.) Science curricula are often a-historical, science is presented as a static body of well-established facts. The relationship to societal issues and daily life situations is often neglected. It is asserted that the neglect of these aspects are detrimental to girls' continued interest to pursue science in their further studies. The perceived image of science and scientists may cause many girls to opt out of science studies. This point will be elaborated in the next section.

To make a simple summary:
Science textbooks are written by men — for boys.

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Example 7.36: Local role model of a woman in science

School System: Australia - secondary school science
Approach: Report of interview with a local woman scientist to provide role models for lessons about equal opportunity - extract only
Source: Parker, Lesley "Scientist Viewpoint - Dr Diana Marmion Temple" The Australian Science Teachers Journal, Vol 35 No 3 August 1989 p 113.

Dr. Diana Marmion Temple is Associate Professor of Pharmacology at the University of Sydney. She grew up in Western Australia, and was educated at Kalgoorlie High School and the Universities of Western Australia and Sydney, where she was awarded BSc, MSc, PhD degrees. Her early training in chemistry was adapted to medical fields and for more than twenty years she has taught and researched in the area of pharmacology. She is involved in much administration and committee work, some of which is related to women's position in science. She is a former Honorary General Secretary of ANZAAS, and is active in WISENET (Women in Science Enquiry Network), convening the Sydney branch of the association.

Q. *What was the strongest factor which led you to become a scientist?*

A. Firstly, from earliest days I had a general interest (encouraged by parents) in the why, how and wherefore of things around us, combined later with practical competence and enjoyment of experimentation. Secondly, in mid-secondary education, I made a pragmatic decision to choose subjects and courses at school and then university that would be likely to provide opportunities for a long-term career and varied employment options. This decision (for chemistry) and particularly for a career commitment, was rather eccentric in a young female student in the 1940s.

Q. *What do you regard as your most significant scientific achievement?*

A. As a medical research scientist, my work has helped to elucidate aspects of how certain medications function in their job of alleviating asthma or allergic reactions. An original observation that I remember with some pride was the effect of sulfur dioxide, common as an air pollutant and food preservative, in inducing asthmatic attacks in certain hyper-reactive persons; this effect was quantified in my laboratory and related to SO_2 dose, and I showed by experiment how individuals could be protected from this effect by the use of certain medications, including some used in asthma therapy.

Q. *Do you have any favourite anecdotes about your work as a scientist, humorous or serious, which illustrates the rewards or frustrations of scientific research?*

A. Scientific research can be enormously exciting and rewarding, as well as often frustrating and sometimes tedious. The breakthroughs and discoveries, the tiny pushing back of the boundaries of knowledge in your own field, for most people come all too rarely, but when they do they shine a light on your life. Without providing any anecdote, I think that young people at decision-making stages need to be told that many (most?) scientists find laboratory work stimulating, and that it can be fascinating, though, like teaching, not always.

Q. *What do you regard as the most interesting and/or important new development in science today?*

A. Recent developments in molecular biology, genetic engineering and immunology seem to be enormously significant

Example 7.37: Internationally famous women biologists

School System: Australia senior secondary biology

Approach: Brief biographical notes (including quotations) about famous women biologists to serve as role models in lessons dealing with equal opportunity issues

Source: Hawes, James; Macinnis, Peter; Meyer, G. Rex, and Stanbury, Peter Biology Data and Resource Book. Melbourne: Longmans Cheshire 1983.

Rachel CARSON (1907 – 1964)
Rachel Carson was the first to popularize what is now called the "ecology movement". Her background included work for the US Fish and Wildlife Service, both as a research scientist and as an editor. These experiences gave her both the awareness and the ability to write the best-selling *Silent Spring* in which she attacked the excessive use of chemicals in pest control.

> These insecticides are not selective poisons: they do not single out the one species of which we desire to be rid. Each of them is used for the simple reason that it is a deadly poison. It therefore poisons all life with which it comes in contact: the cat beloved of some family, the farmer's cattle, the rabbit in the field, and the horned lark out of the sky.
>
> These sprays, dusts and aerosols are now applied almost universally to farms, gardens, forests, and homes ... Can anyone believe it is possible to lay down such a barrage of poisons on the surface of the earth without making it unfit for all life? They should not be called "insecticides", but "biocides".

Mary D. LEAKEY (1913–)
Mary Leakey is the widow of Louis Leakey. During his life, she was his partner, and since his death, she has continued their work. An archaeologist, it was Mary who first discovered the fossil skull of *Zinjanthropus* (now called *Australopithecus boisei*). Most people think of Olduvai Gorge when they think of the Leakeys (three sons and a daughter-in-law are also involved), but Mary Leakey says

> ... it is important to realize that Olduvai is not the whole story. Research in other parts of the world preceded ours at Olduvai and important research is continuing in other localities at the present time. In 1978, for example, evidence relating to early man and the contemporary fauna was found in the form of fossilized footprints at Laetoli, a Pliocene site forty-five kilometres south of Olduvai ... Our aim at Olduvai, which we share with all prehistoric archaeologists and palaeo-anthropologists, is to try to determine when and by what steps our ancestors became human and evolved into *Homo sapiens*.

Mary F. LYON
Mary Lyon graduated in zoology, has worked in the field of genetics, and is best known for what is called the Lyon Hypothesis. This was a suggestion she put forward which helped to explain why only female cats could have tortoiseshell coats. Coat colour genes in cats are found on the X chromosome, and she suggests that females cats have some means of randomly "switching off" one or the other of the X chromosomes. She suggests that this happens during development of the embryo, so that in a cat which is a heterozygote, the coat will consist of scattered patches of one colour or the other, each patch being descended from a single cell.

> ... one of the two X chromosomes of female mammals is genetically inactivated or "switched off" at an early stage of development and, although still present in all cells, remains dormant and produces no gene products throughout the further life of the animal. Thus, in effect, both males and females have only a single dose of X-linked genes.

Margaret MEAD (1901 – 1978)
Margaret Mead's specialisation is anthropology, which may be described as the study of the behaviour of human social groups. She has described her work and her conclusions in a number of popular works such as *Coming of Age in Samoa*, as well as in many scientific monographs. The normal method of anthropologists involves living with the human group being studied, and she shows a lively awareness of the advantages and disadvantages of such a method.

> It is realised that in transferring an investigation from within our society where all the instruments of research, particularly language, are under perfect control, to a primitive society where controlled conditions are practically impossible and a new language has to be learned, certain sacrifices of methodological exactness are necessarily made. But it is felt that such disadvantages in method are more than compensated for by the advantages which result from a homogeneous culture ... For studies of personality, social adjustment etc., that is, for all those investigations where the social environment is the most important factor, research in primitive society is rich in its rewards.

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iii) Examples of Project and Test Questions

The following projects and test questions are the suggestions of the author.

. Project. Sex stereotyping in fiction. Many educators say that childrens' story books reflect sex stereotyping. Boys are pictured and written about in a certain way and girls in another. This helps establish prejudice and bias about what boys and girls could and should do.

Go to your local childrens' library and select at random five story books written for children aged about ten. Look through the books and answer the following questions.

a) List down the following words
   creative
   passive
   strong
   dependent
   brave
   fearful
   Count the number of times you could apply these words to the boys and to the girls featured in the stories and draw up a table showing the boys results in one column and the girls in another.

b) Form groups of about five to discuss your results. What can you conclude from the tables put together by the various members of your group?

. Project. Men and women in biology. Look through your biology textbook and make an estimate of the number of times men biologists are mentioned compared with women biologists.

a) What does this simple analysis suggest to you about the relative opportunity for men and women to become biologists?

b) What do you think may be the cause of any differences you discovered?

. Project. Sex stereotyping in behaviour. Most people expect boys to behave in a certain way and girls in another.

a) List some of the ways boys are expected to behave that are different from girls.

b) What things are girls expected to do which boys are not?

c) Discuss whether these sex differences are due to inheritance or learning.

d) What influence do you think these differences may have on a choice of a career?

- Project. Sexism. Find out what you can about the following.

  Sexism
  Women's liberation
  Equal opportunity in employment

  Answer the following questions.

  a) Explain in terms of the cultural evolution of humankind how sexism may have developed in society.

  b) What main biological factor caused the women's liberation movement? Why did it have such an important effect on the behaviour and roles of women in society?

  c) Explain why so few women become research biologists compared with men. What could be done to increase the participation of women in this type of work?

- Test Questions

1. Draw up a table to show the changes in the structure and function of the bodies of boys and girls at puberty. Use the following headings.

   Body and facial hair
   Sex organs
   Glands and hormones
   Muscular development
   Height and weight
   Breasts

2. Here is a description of two people based on how they were depicted in a story book.

   Person A. Brave and strong and very good at sports. Clearly a leader able to influence others in a big way. Never lets others say what must be done. Would answer back strongly and may even fight if opposed. Collects stamps.

   Person B. Generally quiet and likes to read. Keen on painting and music. Will not push forward and is generally satisfied to follow the lead of others. Not very good at sports. Always anxious to help other people. Very interested in clothes.

   a) Which do you think was a boy and which a girl? Why do you say that?

b) Write a few sentences about why fiction writers tend to describe boys and girls in such different ways.

3. Briefly explain why so few women become professional biologists. Make some suggestions about how more girls could be encouraged to become biologists.
[Write about 2 pages]

4. Here are some specific situations in regard to the roles of women in society. For each situation write one hypothesis to suggest how the situation may have come about.

    a) In a large city in a developed country 80% of the workforce in the garment industry are women.

    b) In the rural areas of a poor country all the women must work in the fields as well as look after their families.

    c) In developing countries overall 33% of all women are illiterate compared with 23% of men.

5. The advent of fail-safe contraception has enabled more and more women to enter the workforce - especially in developed countries. Explain this. [½ page]

6. In a particular country the situation in regard to men and women in terms of educational and work opportunity can be summarised as follows.

	% Men	% Women
Proportion finishing primary school	70	50
Proportion of adult illiterates	25	35
Proportion of adults in paid employment	75	40

    a) Plan an educational programme for the country specifically aimed at improving the status of women. [2 pages]

    b) How could a knowledge of biology be applied to help women improve their education and general standard of living. [2 pages]

Notes and References

Note: Sources of exemplar materials are cited in the text and are not included in this list.

(1) See accounts of the psychology of need in basic references on psychology such as:
Perkins, Hugh V. Human Development and Learning Second Edition. Belmont, California: Wadsworth 1974

(2) Meadows, Donella H. Harvesting One Hundredfold Key Concepts and Case Studies in Environmental Education. Nairobi: United Nations Environment Programme 1989 pp 9-10

(3) Morley, Brian Population Ecology (National Science Curriculum Materials Project B10). Milton Queensland: Jacaranda Press 1971

(4) For example see Birch, L.C. (Chairman) Senior Science for High School Students Part 3 Biology. Sydney: Nuclear Research Foundation within the University of Sydney 1966

(5) This approach was given a strong impetus by authors such as Paul and Anne Ehrlich. See for example:
Ehrlich, Paul R., Ehrlich, Anne H. and Holdren, John P. Human Ecology Problems and Solutions. San Francisco: W.H. Freeman 1973.

(6) See for example:
Jamaica Ministry of Education Family Life Education Project Source Book for Teachers. Kingston: Ministry of Education 1986
Note: This reference has been used extensively for section 7.4.

(7) Meyer, G. Rex "Current Issues in Bioethics: An Educator's Response" Biology International (Special Issue No 11 - "New Challenges for Biological Education") 1986 pp 23-30

(8) McInerney, Joseph D. "Ethical Values in Biology Education" in Frazer, M.J. and Kornhauser, A. Ethics and Social Responsibility in Science Education (Science and Technology Education and Future Human Needs Volume 2). Oxford: Pergamon Press for the ICSU Press 1986 pp 175-181

(9) Kelly, Peter "Biology and Ethics: A Theme and Variation" Journal of Biological Education Vol 24 No 1 1990 pp 18-22

(10) Meyer, G. Rex The Bioethical Need in Modern Education. A paper presented to the Eleventh Annual Meeting of the Commission for Biological Sciences of the International Union of Biological Sciences, Moscow, September 1-8, 1989

(11) In particular see Brumby, Margaret "Teaching and Learning About Issues in Biology" in Unesco: New Trends in Biology Teaching Volume V. Paris: Unesco 1987 pp 45-57

(12) For a review of principles and teaching methodologies in the area of bioethics education see Meyer, G. Rex Bioethics Education. Hamburg: Lit for IUBS-CBE 1991

(13) Rao, A.N. "Biology of Leisure" in Meyer, G. Rex and Rao, A.N. Teaching Science Out-of-School with Special Reference to Biology. Singapore: IUBS-CBE and the Asian Network for Biological Sciences 1984 pp 47-52

(14) For an account of sex stereotyping see standard references on psychology. For example: Perkins, Hugh Human Development and Learning Second Edition. Belmont California: Wadsworth 1974

Chapter 8

DEVELOPMENT NEEDS - BIOLOGY TOPICS WITH A FUTURE ORIENTATION

8.1 Introduction

Chapter 6 reviewed how a socially oriented programme of secondary school biology may possibly address at least some of the personal needs of students. Chapter 7 examined some of the normative needs of society at large, especially those of immediate concern such as family life, understanding population issues, bioethical issues, effective use of leisure time and the like.

Chapter 8 takes a still broader view examining bigger issues such as management of resources, technological development, the management of change, determination of national science policy, national planning and development and international issues. While all biology education should have a future orientation, the topics reviewed in this chapter point more strongly to the future than perhaps some dealt with in Chapters 6 and 7.

In a socially oriented programme of school biology a central aim should be to prepare students to take their place as contributors to the wellbeing and positive growth of the community and of the nation. This implies that they must develop the powers of critical reasoning and problem solving. They should see the broad implications of what they study at school and not become lost in the detailed trivia of any particular area of knowledge.

In particular if secondary education is to be effective it must develop attitudes of tolerance and empathy in relation to others and to the concerns of society. Tolerance of ambiguity or ability to resolve conflicts and an interest in and willingness to face up to complex issues are indicators of maturity and of an autonomous personality (1). Those aspects, extensions and applications of biology which foster these skills should be highlighted.

Further if any nation is to develop economically and socially in such a way as to improve the quality of life of all its citizens, then all its citizens should be sufficiently educated to become involved in democratic decision-making at all levels. This implies they should have a reasonably objective outlook, a good general knowledge and the ability to analyse social issues of the day and to plan policy and action. School biology can contribute to the development of a democratic knowledgeable society through the judicious selection of biologically based community, national and international issues. By developing the immediate and longer term skills necessary to resolve difficulties and to face up in a meaningful way to the resolution of personal and societal conflicts, school biology becomes a power for positive change and not just a body of factual knowledge learnt for its own sake or to pass a public examination.

Certain of the topics covered in this chapter, therefore, depart from what many may consider to be the province of biology. But the author defends their inclusion on two grounds. The first is that they represent logical extensions of main-stream biology from a purely disciplinary framework to the broader framework of society as a whole. The second is that problem solving, critical thinking and skills of planning and of policy making, if limited to purely formal aspects of the subject, simply will not transfer to the world outside the classroom. Yet if the world is to have a future of positive wellbeing for all, then that transfer must occur. It will only occur if bridges are built between the subject matter of biology and the subject matter of everyday life.

8.2 **Biology Teaching and Scientific Literacy**

i) Rationale

Educators world wide appreciate that "few of the major problems of modern civilization can be dealt with in the absence of scientific literacy. There is a realization that an understanding of science is imperative in the education of all people" (2). By scientific literacy is generally meant "the ability to perceive, comprehend, interpret, explain and predict natural phenomena and to demonstrate such ability technologically" (3). However, as stressed by Kenneth Prewitt in his insightful article in the Spring 1983 issue of Daedalus it is important to recognize that the public in general can never be fully educated in the intricacies of the various science-based debates which confront us from time to time. Prewitt believes that scientific literacy "starts at the point of interaction between science and society" and that a scientifically literate person "understands how science and technology impinge on public life" (4).

It is generally agreed that there are three components to scientific literacy - a knowledge component, a process or methodological component and an applied or socially relevant component (5). By scientific knowledge is meant those key concepts that underpin understanding of our complex technologically based society. All citizens should be able to read, understand and communicate about the many science messages they confront every day - on food labels, medications, in advertising, in the mass media and in their general reading. This represents a part of an expansion of general knowledge in a truly autonomous individual and it is upon this that rests the ability to make rational decisions - the basis of democracy (6).

The important Bangalore conference of 1985 on Science and Technology Education and Basic Human Needs sponsored by Unesco and the Committee on the Teaching of Science (CTS) of the International Council of Scientific Unions (ICSU) therefore argued that literate adults should be knowledgeable in all the following areas of science (7).

(1) Health
(2) Food and Agriculture
(3) Energy
(4) Land, Water and Mineral Resources
(5) Industry and Technology
(6) The Environment
(7) Information Transfer
(8) Ethics and Social Responsibilities

Suggestions about what a literate adult should know about science assume only knowledge at a minimal functional level. It is not expected that all adults, nor even the average adult, should be able to read and understand journals such as *Nature*, *Science* or even *Scientific American* and *The New Scientist*. What is assumed is that a scientifically literate adult can understand those basic scientific concepts likely to be met in everyday life to the point where the meaning of the concept is sufficiently clear for personal decision making.

The process component involves an understanding of the nature of science and of the scientific approach. This includes knowledge and skill in experimentation, reasoning, theory building, problem solving, creative design and building of models, critical evaluation and the like (8).

The applied component involves the ability to solve science-based community problems, to plan actions using science knowledge or processes and to participate in determining science and science-related policy.

There is a further dimension to the issue of scientific literacy. This is that biology teachers share with all teachers the responsibility of building general skills of communication including thinking, speaking, reading, writing and numeracy. These more general literary skills enable more specific scientific and biological literacy aspects to be developed and like the more specific scientifically related skills, they need to be addressed directly and not through some hidden agenda.

The challenge for the biology teacher is to recognize that biological aspects of scientific and indeed general literacy must be deliberately and overtly developed. In the past it has been assumed that if the traditional topics of the biology curriculum are followed with sufficient rigour, then it will automatically follow that learners will become generally and biologically literate. This is a false idea since transfer will not occur unless appropriate programmes and activities are provided to build the links between the science of the classroom and the science of the real world.

ii) Examples of Content

Example 8.1: Scope of scientific literacy

School System: USA State of Louisiana secondary school biology

Approach: Curriculum Guide to stress the underlying scientific literacy dimensions of the Year 10 Secondary School Biology Programme

Source: State of Louisiana Department of Education Biology I Curriculum Guide Bulletin 1646. Baton Rouge: Louisiana Department of Education 1984 revised 1988 pp xiv-xv.

GOALS OF TEACHING BIOLOGY I

Science Literacy

The primary goal of science courses in grades K-12 is to promote science literacy. Before determining what should be taught, science literacy should be defined. Science literacy is the ability to perceive, comprehend, interpret, explain, and predict natural phenomena and to demonstrate such ability technologically. Many science educators recommend that science literacy should not be a separate entity but an integral component of the total curriculum. The perception, comprehension, interpretation, explanation, and prediction of a phenomenon should be fused into every area of the curriculum.

According to most science educators, a scientifically literate citizen should be:

1. aware that science is concerned with the empirical universe.
2. able to read accounts of developments by the scientific community.
3. aware that knowledge developed in the scientific community is probable rather than absolute.
4. aware of the difference between theoretical and empirical concepts and laws.
5. aware of how both empirical and theoretical concepts and laws come into being.
6. aware of the scientifically accepted regulatory principles.
7. aware that theoretical and empirical laws may be descriptive, comparative, or quantitative.
8. able to use theoretical laws in unifying empirical laws.
9. able to use empirical concepts and laws in a constant adjustment to the environment.
10. able to explain and to predict events in the environment in a rational manner.
11. able to translate experience of the natural world into knowledge.
12. able to communicate with other citizens about knowledge and ideas about natural objects and phenomena.
13. able to communicate with other citizens about the use or control of natural objects or forces.

Specific Goals

Achieving science literacy involves attitudes, process skills, concepts, and social aspects of science and technology. This literacy is linked to a global awareness that knowledge is increasing at a tremendous rate and that this rapid increase affects society in a great variety of ways. Based upon this belief, the following major goals of science are stated:

1. Fostering Positive Attitudes Toward Science and the Scientific Process

Developing a deep appreciation of the role of science and the scientific process will influence the way students think about the environment and about their effect on the environment.

2. Developing Process Skills

The development of process skills is an integral part of science activities for students. Students should be given opportunities to develop those intellectual processes of inquiry and thought by which scientific phenomena are explained, measured, predicted, organized, and communicated. These experiences will serve to reinforce scientific concepts.

Basic Scientific Process Skills used in solving problems and making decisions include observing, inferring, classifying, using numbers, measuring, using space-time relationships, communicating, predicting, and designing experiments. Integrated Process Skills include controlling variables, defining operationally, formulating hypotheses, interpreting data, and experimenting.

3. Acquiring Knowledge

Included in the basic science curriculum are those scientific concepts, principles, theories, and laws that will enable the students to understand and interpret natural phenomena. Applying scientific concepts, principles, theories, and laws requires the understanding of cause-effect relationships; energy-matter relationships; time-space relationships; revolutionary, evolutionary, or catastrophic change; interaction of variables; systems; symmetry; and equilibrium.

4. Recognizing the Interaction of Science, Technology, and Society

The students should (a) understand the interrelationships of science, technology, and social and economic development, (b) recognize both the limitations and the usefulness of science and technology in advancing human welfare, and (c) understand the concept of global ethics when new technologies are used. Science and technology are difficult to separate because scientists often develop new technology and new technology produces new avenues for scientists to obtain new knowledge. Changes in science and technology may not always improve society and may be the subject of moral, religious, or ethical questions. Such controversial issues cannot be solved in a science classroom but may be discussed.

Example 8.2: Process component of scientific literacy

School System: USA. State of Kentucky secondary school biology year ten
Approach: Curriculum guide with suggested learning activities for developing an understanding of the process component of scientific literacy
Source: Kentucky Department of Education Science Skills Continuum. Frankfurt: Kentucky 1988 pp 8-12.

1.0 OBSERVING Recognize characteristics of living things. Observe an interrelationship between living and non-living components of the environment. Recognize differences and similarities of different life forms. Observe cyclic changes of living organisms within the environment.	1. List common characteristics of a set of organisms. 2. Diagram the interrelationship observed within an ecosystem. 3. Identify the differences and similarities of a group of organisms. 4. Illustrate and label the cyclic changes of a particular organism.
2.0 CLASSIFYING Categorize organisms on the basis of structure and function. Sequence the stages of events according to order of occurence (i.e., plant succession, life cycle).	1. Categorize a group of invertebrates according to their similarities and differences. 2. Identify three stages of plant succession in a natural area. 3. Place in sequence the metamorphic stages of an insect.
3.0 INFERRING Explain possible causes for observable events based on previous knowledge and/or experience.	1. Suggest possible causes for yellowing and wilting of a plant. 2. Infer which of two water sources (i.e., pond in a forested water-shed, pond polluted by agriculture waste) supports the greatest diversity of life forms. 3. Infer which animal made which set of tracks when presented with two sets of pictures, one showing a group of animals, and one showing sets of tracks.
4.0 PREDICTING Predict an outcome of an event based on previously observed conditions. Predict the consequences of removing or altering one or more elements in a system. Interpolate or extrapolate conclusions when given appropriate data (data tables, graphs).	1. Predict the methods of seed dispersal based on observing several seeds or seed pods. 2. Predict the final state of succession for a geographic area.
5.0 MEASURING Quantify information by measurement on scales, graphs, diagrams, and other visual materials.	1. Record data on the growth patterns of a variety of organisms. 2. Conduct a population survey of the various hardwoods in a given area. 3. Construct a bar graph on the basis of time and plant height. 4. Plot the locations and species of trees within an area on graph paper.

6.0 COMMUNICATING Describe orally, or in written form or by drawings and diagrams an object, event or idea for the understanding of others. Listen attentively in order to grasp the communication of others.	1. Present, orally or in written form or in graphic detail, information obtained from a field trip or investigation. 2. Present, orally or in written form, information obtained from the library using various sources (i.e., card catalog, reader's guide, etc.) on a given topic. 1. Follow oral directions for an investigation.
7.0 INTERPRETING DATA Extract the important ideas from reading, listening to, or watching presentations containing scientific information. Read numerical values from charts, tables or graphs and apply the results to answering questions.	1. Interpret the age of a tree, climatic changes and evidence of fire and diseases from observations and recorded data of the growth rings of the tree. 2. Extract and present the numerical data obtained from a graph on growth rate of yeast populations.
8.0 MAKING OPERATIONAL DEFINITIONS Explain the physical circumstances under which the experiment or concept must operate. Identify a method of measuring phenomena.	1. Define osmosis by describing the behavior of iodine as it passes through dialysis tubing into a starch suspension. 2. Define an aquatic ecosystem by identifying the balance necessary between the biotic and abiotic factors.
9.0 FORMULATING QUESTIONS & HYPOTHESES Raising uncertainties and tentatively accept an explanation as a basis for further investigation.	1. Formulate a hypothesis from a problem stated in researchable terms. 2. Eliminate duplication from a group of hypotheses devised from one problem. 3. Formulate questions in terms that can be researched.

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10.0 EXPERIMENTING Recognize an appropriate sequence related to a laboratory investigation.	1. Isolate a problem, gather data, suggest a hypothesis, develop an experiment with variables and controls, interpret results, draw conclusions, and make predictions. 2. Identify potential independent variables.
11.0 FORMULATING MODELS Demonstrate knowledge that models are used to explain phenomena that are not understood completely or observed directly.	1. Construct a model for osmosis in a living cell after completing investigations using dialysis tubing and different starch concentrations.

Example 8.3: Social applications component of scientific literacy

School System: United Kingdom. Science in Society Programme for secondary schools
Approach: Description of audio cassette programmes on specific topics
Source: Science in Society Newsletter. London: Heinemann Educational Books for the Association for Science Education 1983.

Audio Programmes

Of 15 minutes each on cassette, presented in seven units, each unit with its own Teachers Notes. They are designed to provoke discussion in the classroom. Programmes include:

CARE OF THE AGED (Jack Jones/Dr. William Davison) - from Unit 1.

What is society's responsibility towards the older people amongst us? What is the family's responsibility? What is the doctor's responsibility?

Jack Jones "It is just as essential to find the means to provide comfort and happiness for those who are too old to work and yet too young to die as it is to provide schools for children."

William Davison "In that sense I practise euthanasia. But I will not kill on demand."

IS PROFIT IMMORAL? (Lord Goodman/Dr. F.E. Jones/Dr. Oonah McDonald) - from Unit 5.

Why does industry need to make a profit? How can we ensure that profits are not excessive? Can they be regulated without impinging on personal liberty?

Lord Goodman "A society totally devoid of profit would, to most people be a dull society, a stagnant society, a society in which people were less happy ... because regulating the amount of profit that people can have has been found to be a means of regulating the amount of liberty they can have."

IMPACT OF THE NEW TECHNOLOGY (Barrie Sherman/Professor Tom Stonier) - from Unit 7.

Nobody will be unaffected by the new technology. The period we now live in is a watershed. What of the immediate and the long term social effects?

Barrie Sherman "The first 20 years of the new Industrial Revolution will be traumatic. There will be periods when there is not enough work. For those without qualifications there will still be jobs - the dirty, unpleasant, badly-paid ones. The rest of the jobs will be open to people who know about computers, data bases and systems."

Tom Stonier "Over the next two or three decades the workforce engaged in producing food, clothes, textiles, furniture, cars, housing and electricity will shrink to 10 per cent or less. The manufacturing sector will create wealth - not jobs. There may come a point - 50 years away - when we can afford negative income tax."

THE NUCLEAR THREAT (Professor Adam Curle/Sir Herman Bondi) - from Unit 7.

Both East and West are stockpiling weapons to deter the other side. Are countries that have such weapons so terrified of an ordinary war becoming a nuclear one that it stops them fighting, or do nuclear weapons increase the danger?

Adam Curle "We're coming to the stage where the fear that previously had prevented people from attacking each other might now be what makes them attack. They may think: we're going to be attacked in any case; let's get in first."

Sir Herman Bondi "Unilateral nuclear disarmament would be appallingly dangerous. It would greatly increase the risks of nuclear war, greatly increase temptation and introduce uncertainty and fear into the world."

SCIENTISTS AND THEIR RESPONSIBILITY (Lord Ashby/John L. Lewis) - from Unit 6.

Many scientific discoveries have brought mankind not only great benefits but also grave consequences - pollution, industrial disease, horrific weapons of war. Should scientists do work whose results they know might harm people?

Lord Ashby "I must confess that here I have to remind myself that I as a scientist, am really two people. When I'm doing science I have my profession but when I'm at home with my wife and my family and my grandchildren, I'm just an ordinary citizen and it's on these occasions that my conscience has to be used to decide whether or not I should work on subjects which might harm not only my wife and children and grandchildren but all sorts of other people."

LOOKING TO THE FUTURE (Kenneth Dadzie/Lord Kearton/Shirley Williams) - from Unit 7.

Three speakers look ahead and give their personal views on what the future holds. Particular reference is made to the prospects for peace, for full employment and for greater opportunities for Third World development.

Shirley Williams "Much of world trade in the next 40 years will be information and library services, banking, insurance, travel and tourism ... there is a great danger that the domination of the English-speaking West in broadcasting, television and information could be a new 'information imperialism'. Frail local cultures must be protected so that they can make their own contribution."

Example 8.4: Developing writing skills through science teaching

School System: Australia. New South Wales secondary schools

Approach: Curriculum guide and suggested activities for improving general literacy skills in science classes

Source: NSW Department of Education Writing K-12. Sydney: NSW Department of Education 1987.

Science and Agriculture

Forms of writing

1
- *stories in Science and Agriculture, especially science fiction*
- *personal reports and descriptions of observations*
- *plays, poems and cartoons*
- *formal reports on laboratory work and excursions*
- *definitions*
- *essays and extended answers*
- *explanation of own understanding*
- *designing science puzzles and board games*
- *analysis of data*
- *notemaking and lecture record keeping*
- *keeping a diary or learning journal*
- *graphic presentation*
- *constructing an interview questionnaire*
- *designing advertisements or captions for cartoons or photographs.*

Using writing to learn

2 Have students keep a draft work book for rough work, draft writing, notemaking and sketching along with a record book for edited permanent work.

3 Begin the lesson with sustained writing about the previous day's work, starting with key words, extending into sentences and linking sentences into paragraphs.

4. Use stimulus questions to elicit answers; structure questions to build up an extended answer for notemaking, research assignments and review of work.

5. Use imaginative writing; for example, *I am Joe's heart*, or the biography of a molecule of carbohydrate through the digestive tract.

6 Students lacking language skills can nevertheless engage in useful writing activities in Science.

7. **The extended answer**

7.1 The extended answer is a very important form in Science and Agriculture. Here is one method of developing the skills required:

- Make sure that the students are familiar with the criteria by which extended answers are to be assessed. These might include
  - ★ relevance to question
  - ★ accuracy of facts
  - ★ coverage of facts
  - ★ balance of presentation, that is, all parts of the question covered adequately
  - ★ provision of supportive evidence or examples
  - ★ use of appropriate register
  - ★ clarity of expression.
- Work with the students, analysing the question and underlining the key words.
- Discuss with them the most appropriate form to use to answer the question; for example, a diagram, tables, paragraphs with headings . . .
- Have the students jot down all the points they can think of that might be relevant to the topic. In the early stages of teaching extended answer writing, these can also be written on the chalkboard or on overhead. This allows the teacher to demonstrate techniques for organising the content.
- Help them clarify and order their thinking as they select the points that are relevant, and arrange them in a logical order. This can be done on the chalkboard with the whole class or in small groups.
- Set them to work either in small groups or individually writing a first draft. Encourage them to concentrate on ideas and answer the question rather than stopping to worry about spelling, punctuation and paragraphing.
- When they are ready, they share their draft with other students or the teacher, conferencing about their own and others' writing. This is the most effective place to intervene and point out where improvement is necessary in organisation or choice of material. Students then revise and submit their writing for assessment. When their writing is assessed, the original criteria must be used.

7.2 Initially, this process will take time, but with experience and practice, students will develop speed and fluency. Most importantly, this is valuable learning time. At the same time as students are learning to master the extended answer form, they are also learning the subject matter. As they plan, draft and revise their answer, they work through the material several times, increasing their understanding of it as they write.

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8 Report writing

Section B, p.88, on report writing

8.1 Report writing is a skill required by all Science and Agriculture students. It is a complex, interactive process, the skills of which must be taught. It should be introduced gradually, at appropriate stages as writing and reporting skills develop.

8.2 Initially personal and informal forms of reporting are more appropriate than the classic report style. As students gain skills and confidence, the formal report format and the use of the third person and passive voice can be developed.

8.3 The report might include the following components:

- determination of the hypothesis, aim or purpose
- selection of a suitable format
- recording of data
- analysis of results
- making of relevant deductions or conclusions after discussing observations or results.

8.4 The process of writing a report involves

- discussion of the components
- the preparation of a draft
- the discussion and amendment of this draft in a small group or whole class
- revising leading to the production of a finished report.

8.5 Discussion of the draft involves an assessment of

- the clarity and conciseness of the presentation
- the validity of the deductions and conclusions
- the appropriateness of the register.

8.6 Reports from scientific sources are useful models.

8.7 However report writing is taught, students should be aware of the characteristics of an effective scientific report so that they can confidently assess the quality of their own reports and can appreciate the criticisms and assessments made by others.

9 Narrative and imaginative writing

9.1 Traditionally, most writing in Science has been report writing and formal written responses to questions. Personal writing is also important as, by engaging in personal reflective and exploratory writing about their experiences and ideas, students can come to an understanding of Science as a process.

9.2 Personal writing can be especially appropriate for the earlier years and the more concrete thinking levels. However, in certain contexts, it can be appropriate for abstract thinking as well.

9.3 Teachers can encourage imaginative writing in Science and Agriculture by

- providing students with stimulus material, such as pictures, films, videos, discussion topics, ideas about science and experiences in science (see Kay Moechtar, *Creating Opportunities for Writing in Science*, Catholic Education Office)
- providing students with the time to discuss, draft, revise, publish and get responses to their imaginative writing. They might publish their writing
    - ★ on the laboratory wall or noticeboard
    - ★ in the school newspaper
    - ★ on school noticeboards
    - ★ in the school library
    - ★ in local newspapers
    - ★ in junior classes.

9.4 When students write for readers other than the teacher, they see that their writing is a real piece of communication and that they are valued as writers. This in turn encourages them to make a real effort to write well and to write more often.

iii) Examples of Project and Test Questions

The following project and test questions suggested by the author.

- Project. Social report. A local municipality plans to build an express motorway through one of the last remaining areas of natural bushland in the district. Your class plans to submit a protest based on a carefully prepared report.

(a) What types of information would you need before you could write the report?

(b) How can you find out what animals and plants would be destroyed by the motorway?

(c) Set out the headings and subheadings of the report you would prepare.

- Project. Talks on science and society. Here are six subject topics from biology.

  Photosynthesis
  Digestion
  Diversity
  Population ecology
  Inheritance of human characteristics
  DNA

  Form into six discussion groups and each group select one of the topics. Prepare an outline of a talk you would give to a local group of parents under the title "What this topic means in your everyday life". Each group should elect a spokesperson who should describe that group's planned talk to the class as a whole.

- Project. Creative writing about biology. Write a short poem or play on one of the following topics:

  Forest animals
  Life in water
  Frogs

- Project. Bulletin board. Prepare a bulletin board and pin up articles from local newspapers and magazines dealing with any aspects of biology. After one or two months study the material on the bulletin board and answer the following questions.

  (a) What does the material suggest may have been the main concerns of the mass media over the past month or so in biology related areas?

  (b) Choose one of the stories. List down the areas of biology you would need to study if you wanted to investigate the story in greater detail.

  (c) Select articles which give different points of view about the same issue or problem. State what the stories have in common and in what ways they are different. How could you find out which is the more scientifically accurate account?

. Test Questions

(1) Design an experiment to test whether or not a certain brand of insect repellent which is widely advertised on television and radio is as effective as other brands which are not so well advertised.

(2) Here are three descriptions of events that a local gardener observed during a particularly hot summer.

   (a) Some summer types of shrubs wilted badly while others did not.
   (b) Seedlings which normally flowered well, flowered very poorly.
   (c) Certain areas of the garden soil retained moisture much more than others.

   For each event write one hypothesis to explain what may have been the cause.

(3) Studying biology should help you (i) keep healthy, (ii) get a good job after leaving school and (iii) get the best out of your leisure time. For each of these three list some useful biological topics which would help you get the best results.

(4) In three weeks time your school intends to give a full day to help the local Council clean up a small area of bushland which has become badly littered with rubbish. Describe a clear plan for organizing and completing the clean-up day.

(5) Write an article of 200 words for your school newspaper on a biological topic which you think would interest parents.

8.3 Biological Education and Technology

i) Rationale

In a formal dictionary statement technology is defined as the "scientific study of industrial and mechanical arts" (9). Biological technology involves those aspects of the study of industrial and mechanical arts which have a basis in the biological sciences. These include aspects of medical technology, agriculture, food processing and so on. A specific term which has come to have a more specialized meaning is "biotechnology" which is now usually used to describe studies of molecular biology, and especially genetical aspects of molecular biology, as they become applied in industrial, medical, agricultural and other activities (10).

A great deal of information is now available to biology educators about past and present aspects of biological technology, and especially biotechnology (11). What a socially oriented programme of school biology should do, however, is not only to review some of these important scientific and technical advances but also to consider their immediate and longer term implications for the future of society.

A socially oriented biology, therefore, should review the differences between science and technology and examine the partnership between them. A useful approach may be to consider science basically as a way of "knowing" and technology as a way of "doing". This in fact is how a new "National Statement on Science for Australian Schools" of the Australian Education Council (AEC) (12) recommends that the issue be addressed. The AEC statement summarizes the differences between science and technology as follows (see table) (13).

Perspective	Scientific	Technological
Essence	A way of knowing	A way of doing
Key Characteristics	. focus on phenomena . analytic . explanatory . theoretical	. focus on applications . synthetic . inventive . productive
Key Processes	. observing . investigating . predicting . applying	. identifying . designing . making . appraising

Another aspect which should receive attention is how basic scientific knowledge actually transfers through applied science to the community at large as the basis of its agriculture, industry, medicine and commerce. The importance and role of this knowledge in bringing about change and in improving the quality of life for all citizens is the key to this analysis. This treatment should then link to issues such as national development and matters such as sustainable economic and social development.

An important more general area for consideration is of course the whole question of international technological transfer, especially between the developed and the developing world. Ethical considerations as well as industrial and technical relations should be examined in this regard.

ii) Examples of Content

Example 8.5: History of biologically based technologies
School System: - *Approach: A history of biologically based technologies leading to the emergence of modern biotechnology - notes for teachers* *Source: Smith, J.E. "The Role of Biotechnology in the Economy of Developing Countries" in Rao, A.N. and Kille, R.A. (eds) Biological Technology and Biological Education. Amman Jordan: Proceedings of the IUBS Commission for Biological Education 1983. Cited in McInerney, Joseph D. Teaching Biotechnology in Schools (Science and Technology Education Document Series No 39). Paris: Unesco 1990 pp 7-9.*

According to Smith (1986), there are four major phases in the development of modern biotechnological practices:

1. *Food and Beverage Biotechnology.*

   This includes processes related to brewing, wine making, and leavening of bread that have been practiced for several thousand years; the Sumarians and Babylonians were drinking beer by 6000 BC, and the Egyptians were making leavened bread by 4000 BC. That these processes were being carried out by microorganisms--namely the yeast *Saccharomyces*--was not recognized until the seventeenth century, with the development of the light microscope. Similar biotechnologies using microbiologically based processes include production of fermented milk products, soya sauce, and various other oriental foods.

2. *Products Initially Developed from Microbiological Processes under Non-sterile Conditions.*

   By the end of nineteenth century, a number of substances including ethanol, acetic acids, butanol, and acetone were produced on a commercial scale. Production employed simple fermentation under selective microbial control through careful manipulation of the environment; complex, mechanical systems were involved. Use of these processes for the production of said substances declined with the development of the petrochemical industry. Recent escalation in oil prices, however, has led to a resurgence in the deployment of fermentation practices. These processes also are associated with waste-water treatment, decomposing, and detoxification of human sewage.

3. *Sterile Practices in Biotechnological Processes.*

   With the introduction of new engineering practices in the 1940s, the pathway of biotechnology changed; allowing the mass cultivation of a microorganisms in pure form in fermenters. Thus, by the prior sterilization of the medium and the fermenters, and through technological provisions to exclude contaminants, it has been possible to use only selected biocatalysts--microbes, enzymes, and plant or animal cells, for example--for industrial production of antibodies, enzymes, aminoacids, polysaccharides, vaccines, and other products. Unfortunately, many such technologies are complicated and expensive, and hence are suitable only for high-value products.

4. *New Dimensions for Biotechnology.*

Modern biotechnology has resulted from:

a. fundamental discoveries in the life science, particularly the discovery of the role of DNA as the carrier of the genetic code;
b. gene-manipulation techniques to create new life forms;
c. microbial techniques for cultivation, screening, and selection of useful cells or microorganisms, and manipulation of their behavior under controlled conditions;
d. immobilization of enzymes and whole cells for biocatolytic purposes;
e. cell- and tissue-culture techniques to accelerate propagations of useful plants; and
f. down-stream-processing techniques for extraction, treatment, purification, and conversion of useful materials following biomass production.

The most important aspect of the modern biotechnology will be its capacity to use agricultural by-products and other organic wastes to produce more valuable products. Biotechnology therefore holds reasonable promise to reduce the scientific and technological gap between the developing and industrialized countries.

Example 8.6: Biologically based technologies in the biology curriculum

School System: UK - secondary school biology
Approach: Correlation between school biology topics and biologically based technologies - information for teachers
Source: Association for Science Education Biotechnology in School: a Report by the Biotechnology Subcommittee. London: ASE 1986. Cited in McInerney, Joseph D. Teaching Biotechnology in Schools (Science and Technology Education Document Series No 39). Paris: Unesco 1990 pp 21-22.

SYLLABUS TOPICS	REFERENCE TO BIOTECHNOLOGY
BIOLOGICAL RESOURCES and their exploitation.	Ethanol (gasohol), methane (biogas); biomass
CELL BIOLOGY SCP;	Fermentation processes; nutrient requirements; cell culture.
COORDINATION. Nervous control.	Use of plant hormones. Insulin production-genetic and hormonal engineering. Sources of hormones used in medicine.
CROP AND LIVESTOCK PRODUCTION/BREEDING	Agriculture - embryo transplants; genetic improvement.
DIVERSITY OF ORGANISMS	Social, economic and technological impact of micro-organisms.
ECOLOGY	Microbial pesticides. Batch and continuous fermenters.
DISEASES AND THEIR TREATMENTS	Antibiotics; immunology/monoclonal antibodies; synthetic hormones; new vaccines; interferons.
ECOSYSTEMS	Importance of bacteria, fungi and algae, the nitrogen cycle; nitrogen-fixing bacteria.
FUELS AND ENERGY	Biomass, gasohol and biogas, use of enzymes as catalysts. Fermentation and alcohol production photosynthesis - ways of increasing the efficiency of plant to absorb and utilize sunlight energy and minerals.
REPRODUCTION, GROWTH AND CELLS	Genetic engineering. Cell and tissue culture.
SCIENCE AND SOCIETY	Genetics. Plant and animal breeding. Economics of processes. Comparison of the use of conventional plant with one using microorganisms.
THE EARTH AS A SOURCE OF MATERIALS	Biomass; formation of oil/gas by bacteria; extraction of metals from ores by microorganisms; renewable sources of materials when supplies of oil, gas and coal run out.
VARIETY OF LIFE	Microorganisms; the importance of enzymes.

Example 8.7: Production of vinegar

School System: -
Approach: *An example of a relatively simple laboratory activity to illustrate the application of biological principles in an industrial process*
Source: *McInerney, Joseph D. (Ed) Teaching Biotechnology in Schools (Science and Technology Education Document Series No 39). Paris: Unesco 1990 pp 168-172.*

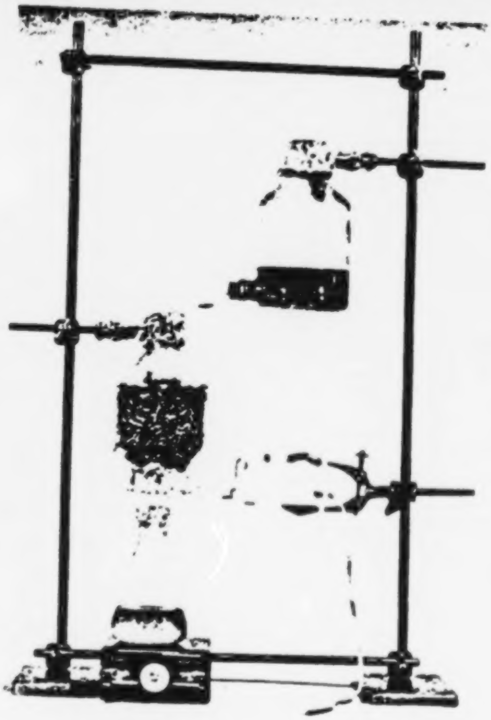
Continuous Production of Vinegar

Prerequisite Biological Knowledge

respiration
fermentation
aerobic and anaerobic microorganisms
knowledge of baker's yeast and wild yeasts
fermentation of acetic acid

Equipment

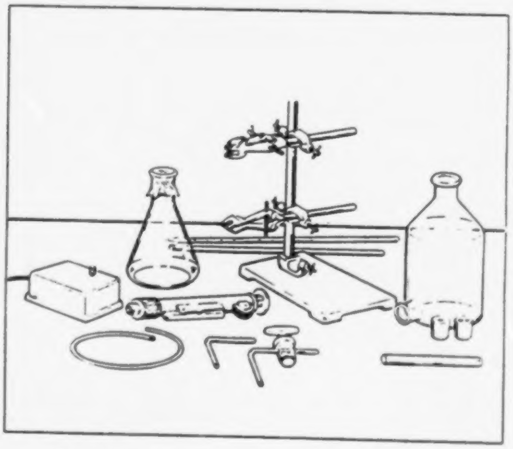
aluminum foil
1 glass tube
1 aquarium pump
1 glass tube, right angled
1 one-way tap, right angled
2 pipettes, 5 ml, sterile
1 conical flask, 500 ml pipetting aids
1 culture tube
1 rubber bung, single bored
2 glass bottles, 1.5 liters with stopper attachments at their bases
1 rubber bung, double bored
rubber tubing
stand material



School fermentation of acetic acid.

Materials

pure culture of *Acetobacter aceti* (DSM-No. 3508)
beech shavings (possibly get a carpenter to rasp some beech strips)
cotton wool
4distilled water
sterilized distilled water, 750 ml
wine (cider or unsulphured port), 250 ml
1 n NaOH



Required equipment.

Time Requirements

preparation and autoclaving of the solutions: 45 minutes
preparation of the culture: 15 minutes
waiting time: 48 hours
construction of fermenter and preparation of main cultures: 45 minutes

Preparation

Resuspend the culture of *Acetobacter aceti* according to the manufacturer's instructions; inoculate the culture with 100 ml medium for the cultivation of vinegar bacteria in a 300 ml conical flask (see appendix). To ensure sufficient addition of oxygen, place the flask on to a magnetic stirrer for 48 hours (the stirring rods should be autoclaved with the culture medium before use).

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Procedure

1. Attach a 1.5 liter bottle that has a fixture for a bung at its base about 40 cm above the table, using the stand. A single-bored rubber bung with an angled, one-way up seals the lower outlet of the bottle where the bung is attached.
2. Attach a second bottle of this kind directly beneath the outlet of the one-way up ("fermenter"). Seal its lower outlet with cotton wool inside; fill its interior with beech shavings.
3. Close the lower outlet of the second bottle with a bung that has been bored through twice. In one of those openings, attach a glass tube as an attachment for the aquarium pump. In the other, insert a right-angled glass tube as a product outlet.
4. Use an aquarium pump to blow air constantly into the inside of the fermenter through the bung; the cotton wool filter keeps the system sterile.
5. As medium, use a mixture of unsulphured port and sterile distilled water in the ratio of 1:4. The pH value must be adjusted to 7.0 using 1 n NaOH. Pour 200 ml of the medium over the beech shavings in the fermenter. Allow the contents to stand for 48 hours.
6. Place the other 800 ml of the medium in the upper container. Adjust the tap so that it releases one drop per 5 minutes.
7. The product is continuously caught in a 500 ml conical flask at a rate of 1 drop per five minutes. Test the product once a day with indicator paper to monitor the development of acid.

Explanations and Suggestions

Step 2. The beech shavings immobilize the vinegar bacteria to the fermenter. The cotton wool should retain coarser particles that can be separated from the wood shavings.

Step 5. The wine must be unsulphured so that the vinegar bacteria do not die off. This is the case in homemade wines and is usually true of ports, as well. The pH value of the medium must be adjusted to 7.0 so that the reduction of the pH value due to the formation of vinegar can be monitored.

Problems and Questions

1. Why is air blown into the bioreactor? (Without oxygen, the vinegar bacteria would die off.)
2. Why must the air be filtered so that it is sterile? (The air in the room contains fungal spores that develop in the fermenter and may cause the formation of mold on the beech shavings.)

Example 8.8: Materials from plants

School System: Proposal for Hong Kong secondary schools
Approach: Suggested practical activities to illustrate simple biology-based industrial processes
Source: Holbrook, J.B. "Technology Education: A Union of Science and Technical Skills" in Waddington, D.J. Education, Industry and Technology (Science and Technology Education and Future Human Needs Volume 3). Oxford: Pergamon Press for the ICSU Press 1987 pp 85-89.

Materials from plants

Under this topic, four products are considered:

(i) soap,
(ii) perfume,
(iii) plant dye,
(iv) paper.

These products are brought together in order to end up with a wrapped, coloured, perfumed bar of soap similar to that available in the local shop.

It is hoped that the study would achieve the following:

(a) appreciation that a bar of soap can be produced by:
  - — the simple process of reacting plant oil with an alkali,
  - — colouring the soap with a plant dye,
  - — perfuming the soap with a perfume extracted from plants,
  - — forming a bar of soap in a mould (through construction of the mould),
  - — wrapping the soap in paper (by producing paper from plant materials),
  - — glueing the paper around the soap to make the finished product, (extensions are possible, for example silk screen printing on the paper).

(b) awareness of the history of soap production and tools of science,
(c) understanding of various conceptual factors in the manufacture of soap, perfume, dyes, and paper, and awareness of what will happen if certain factors are varied,
(d) development of construction skills by making a soap mould and a mesh framework for the production of the paper,
(e) development of manipulative skills through handling the chemicals needed to make soap and for testing the products,
(f) awareness of economic, social and ethical aspects in the production of home-made and industrial soap,
(g) understanding of the cleaning action of soap under various conditions and in comparison with other detergents.

The technical skills involved will be in the construction of the mould (it can be made from wood or plastic) and a framework for paper making (a wooden frame with suitable joints, covered with a wire mesh).

The scientific skills involved would include the making of samples of soap (possibly from different starting materials); simple steam distillation to extract perfume (for example, from orange peel or flowers); solvent extraction of plant dye; breaking down plant fibres and dissolving non-fibrous material to produce paper; handling sodium hydroxide or producing an alkali from wood ash.

Fibres and fabrics

Under this topic, the following are considered:

(i) making a thread by spinning,
(ii) weaving thread to produce cloth,
(iii) dyeing the cloth,
(iv) production of regenerated and man-made fibres,
(v) recognition of fibres and fabrics.

It is hoped that the study would achieve the following:

(a) appreciation how plant material can be made into cloth,
(b) awareness of various forms of dyeing,
(c) appreciation of the need for and the production of regenerated and man-made fibres,
(d) development of a "feel" for fabrics,
(e) understanding the relative merits of natural and hand-made fibres, and the reasons for mixing fibres,
(f) the ability to assess the suitability of cloths for a variety of conditions (for example, moisture retention, resistance to wear, crease resistance, strength of cloth).

The technical skills involved will include testing of strengths of fibres using a simple machine (a problem-solving activity), testing the fastness of dyes (making a simple washing machine), tie and batik dyeing, testing the wear resistance of cloth (involving the construction of a test rig), constructing of a weaving frame and the process of weaving.

The scientific manipulative skills involved would include the examination of fibres under a microscope, production of regenerated and manmade fibres, dyeing cloth, testing fabrics.

Cosmetics

This topic is really an alternative title for the teaching of emulsions and colloids. The following are produced as finished products:

(i) two emulsions (hair oil, handcream),
(ii) one colloid (toothpaste),
(iii) shampoo and lipstick for classification as either colloid or emulsion.

The goals for studying this topic are to understand and recognise emulsions and colloids; to appreciate the reasons for using them; to appreciate the economic, social and ethical considerations surrounding the use of cosmetics and the need for safety standards; to understand the need for care of skin, hair and teeth.

The technical skills involve the production of moulds for making lipstick, etc; packaging cosmetics; silk screen printing (the importance of appearance).

The scientific manipulative skill involved would include making emulsions (oil-in-water and water-in-oil), making colloids, tests for emulsions and colloids.

Example 8.9: Replacement heart

School System: United Kingdom secondary school biology
Approach: A problem solving activity in an area of medical technology
Source: Pritchard, Alan P. Biology and Human Welfare Case Studies in Teaching Applied Biology (Science and Technology Education Document Series No 25). Paris: Unesco 1989 p 43.

This material can perhaps best be illustrated by describing an extension to work on the heart - the design of a replacement heart valve. The authors suggest that the students are asked to:

> "Put yourself in the position of one of the early 'medical engineers'". They then give the following instructions:
>
> > "You have the job of coming up with an idea (or lots of different ideas) for an artificial heart valve. Before you start you need to know one or two things about what will be required - the design features. These are that the valve should:
> >
> > 1. be small enough to fit in the space inside the heart;
> >
> > 2. be able to be sewn in quite quickly and easily (remember that the 'seating' of the valve will gradually heal into the heart tissue and become completely leakproof;

3. be opened and closed simply by the flow of blood;

4. have as few moving parts as possible (so it will be long lasting and won't require servicing);

5. be made of materials that will

   (a) present smooth surface to the blood

   (b) avoid rejection".

They suggest the students work in small groups to bounce ideas off each other and talk to their Craft teachers also. Clearly such an approach not only provides for a technological problem solving aspect, but also gives opportunities to raise issues of the moral, ethical and economic aspects of science and technology. In this case for instance what areas of medical technology are the most urgent to spend money on given the needs of the surrounding community.

Example 8.10: Programmed visits to industry

School System: *United Kingdom secondary school sciences*
Approach: *Instructions for teachers for organizing and conducting a lesson on industrial or commercial premises*
Source: *Chambers, C. "Taking the Classroom to Industry" in Waddington, D.J. Education, Industry and Technology (Science and Technology Education and Future Human Needs Volume 3). Oxford: Pergamon Press for the ICSU Press 1987 pp 191-194.*

Programmed visits

Fundamentally a *programmed visit* is a lesson taught on industrial or commercial premises. The content of the lesson must be an integral part of the school curriculum with the subject matter chosen from an examination syllabus, whether devised internally by the school, or as part of a nationally accepted syllabus for an external examination. The objectives of these visits are:

(i) To indicate the relevance of subject material taught in schools to commerce, technology and industry;
(ii) to enable students to obtain a clear picture of industrial life with its opportunities and challenges.

The content of a *programme* will vary depending on the type of industry involved but will in essence be:

(a) an outline of the essential preparation work to be done in school by the teacher working with the pupils, including examination syllabus references where possible;
(b) a summary of the introductory talk given by a company representative to the students at the start of the visit;
(c) an outline of the site visit including each element of the tour;
(d) work sheets for students to use during their visit;
(e) post-visit material, including problems for homework, or participation in the subsequent classroom discussion of the visit.

In short, a *programmed visit* aims to enable a teacher to begin the study of a subject in the classroom, continue and reinforce this subject by a visit, and complete the work by further classroom discussion.

If the objectives of the programmed visit are to be achieved, a good deal of forward planning is essential, with work done by people on both sides of the link. This work can be divided into several distinct stages.

(i) The initial contact

Very early the backing of senior management is required, and it is to them that the initial approach must be made. If agreement in principle for a visit is reached, a teacher, or preferably, two, must visit the sites for a discussion of the nature of the company's activities. A tour of the site is valuable at this stage.

(ii) The subject of the visit

Frequently, several possible subjects emerge during the initial visit, and it is better to allow a little time for reflection before finally deciding which topic, or topics, are to be the subject of the visit. At this stage of the negotiations misconceptions on both sides of the link can be overcome, and a frank exchange of ideas pursued.

(iii) The initial programme outline

After the first meeting it is possible for the outline of the proposed visit to be prepared. This can be produced by either the teacher or the industrialist, but it is usually done by the teacher.

(iv) The trial visit

Once an outline programme has been produced and agreed by discussion between the teacher and the industrialist, a trial visit can take place. For this visit the teacher will frequently use students from his own school. Any problems which arise, or suggested improvements, can be considered after this visit and necessary modifications made.

(iv) The final programme

A programme draft is produced after the trial visit with all the necessary modifications and this, once agreed by both sides, becomes the final programme for the visit.

The scheme in operation

Once produced the programmed visit material is reproduced and circulated to all schools in the area. The name of an industrial contact able to arrange dates for a visit is included. Each company decides for itself the number it is prepared to accept, the dates when these visits can take place, and the number and ages of children permitted on a given visit.

Every school receives copies of programmes for industries in their area and is able to book directly. This enables students in schools to gain experience of a wide variety of industries. Arrangements can also be made for schools from further afield to visit these industries. The programmes available cover topics as diverse as corrosion and water treatment to company finance.

Advantages of the programmed visit scheme

These can be divided into two sections.

Advantages for industry

It is not the main role of industrialists to educate, and if they do agree to give up some of their valuable time for this work it must be time well spent. Several important points can be made in favour of the programmed visit scheme:

(i) visits are meaningful, aimed at the appropriate level of understanding, and students are well prepared in advance;
(ii) individual planning is not necessary for every visit;
(iii) since visit material is well documented, the same staff do not need to be used for every visit;
(iv) staff involvement in planning visits is limited to the period of the programme production;
(v) students gain a valuable experience of the industry visited.

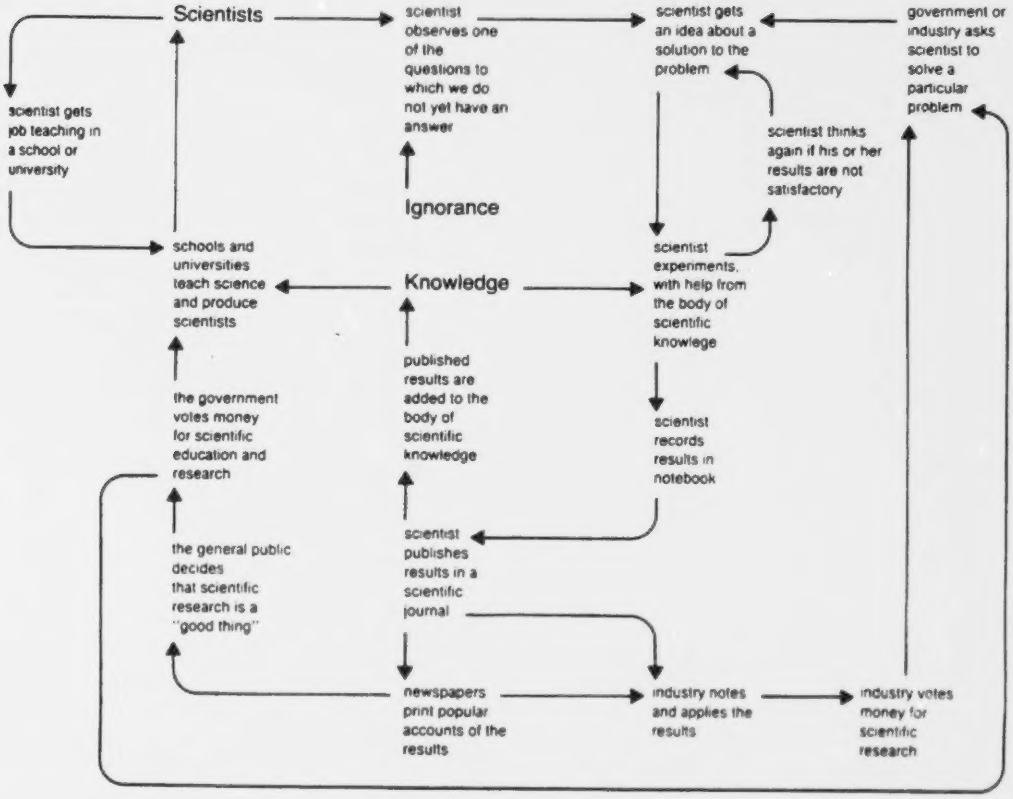
Advantages for schools

(i) Industry is well prepared for the visit;
(ii) students will be able to understand the content of the visit;
(iii) preparative work for the visit is well defined and limited to syllabus material which is relevant to student courses;
(iv) worksheets ensure student involvement in the visit;
(v) visit can be arranged on a range of different subjects;
(vi) the work of a few dedicated teachers and industrialists can benefit a lot of students in many schools.

iii) Examples of Project and Test Questions

. Project. Spread of biological knowledge. Study the following diagram about how biological knowledge is spread in the community. Form into groups of five and discuss the questions which follow the diagram.

How knowledge is spread


Scientists
scientist observes one of the questions to which we do not yet have an answer
scientist gets an idea about a solution to the problem
government or industry asks scientist to solve a particular problem
scientist gets job teaching in a school or university
scientist thinks again if his or her results are not satisfactory
Ignorance
schools and universities teach science and produce scientists
Knowledge
scientist experiments, with help from the body of scientific knowlege
published results are added to the body of scientific knowledge
the government votes money for scientific education and research
scientist records results in notebook
the general public decides that scientific research is a "good thing"
scientist publishes results in a scientific journal
newspapers print popular accounts of the results
industry notes and applies the results
industry votes money for scientific research

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1. Select a key idea in biology (say Darwin's theory of natural selection or the explanations by Watson and Crick of the structure of DNA). Show how the idea was first developed and how it spread and was interpreted by scientists and by the general population.

2. Compare and contrast the roles of scientific journals and the popular press in recording and spreading new ideas in science. Give some examples.

3. "The spread of knowledge about new ideas and discoveries in science is just as important as the discoveries themselves." Do you agree with that idea? Whose responsibility is it to spread knowledge about new discoveries?

4. To what extent to scientists depend on the ideas of other scientists? How do they obtain up-to-date information on the work of others?

5. Industry votes to give financial support to certain scientific projects. How do they get the information needed to make the decision about which projects to support?

Source: Hawes, James; Macinnis, Peter; Meyer, G. Rex, and Stanbury, Peter Biology Data and Resource Book. Melbourne: Longman Cheshire 1983 p 3.

. Project. The human genome. An enquiry into the proposal to map the human genome -activity to review some ethical considerations. (Devised by Professor Peter Kelly.)

An Enquiry into the Proposal to Map and Sequence the Human Genome, by Peter J. Kelly

One of the most significant decisions of our time is that to determine the position and sequence of each of the genes on the human chromosomes. This is an enormous task because each of us has about 100,000 genes and about 3 x 10^9 base pairs in the haploid genome. It also is an enormous responsibility because it will inevitably provide knowledge by which the basic form and function of *Homo sapiens* can be altered fundamentally--for good or ill.

Mapping and sequencing the human genome is an international endeavor with many countries taking part, some with large-scale projects, others with projects concerned with smaller, more specific aspects. There is a coordinating organization--the Human Genome Organization (HUGO)--to facilitate exchange of data and materials, encourage public debate, and provide appropriate information and advice on the scientific, ethical, social, and legal implications of human genome projects. It also is the case that there is competition between countries and, indeed, between individuals and organizations within countries.

Currently, the largest endeavor is in the United States, where, through programs established by the Department of Energy and the National Institutes of Health, more than three billion dollars will be spent. The basic objective is to speed up the rate of research, largely by focusing on the development of new technologies in the early stages of the project. At the previous rate of research, it would be about the year 2500 before a full map and sequence of the genome was obtained. Now, biologists expect to have the complete map and sequence soon after the year 2000.

Many questions arise about the human genome project, some scientific, others to do with economics, ethics, and social issues. To consider and debate these issues, students need to look at them from different viewpoints. A means of facilitating this is to conduct a simulated enquiry or debate on the proposal "That the Human Genome Project be Established." This requires that two assessors and a chairperson be appointed--possibly staff members. Individual students or small groups should be designated as representative of various concerned people and should be required to prepare and debate their case before the assessors. The assessors should then summarize and evaluate the debate.

The following selection of designated representatives could be used; others are possible, as well. Each designation is accompanied by statements on matters raised by such people in the debates that have accompanied the establishment of the actual human genome projects. The students should use the arguments for and against to compile their own views, aided, of course, by their own search for ideas and information.

Scientist

"An understanding of how humans function is one of the ultimate objectives of science, particularly of human genetics. The human genome project will help us meet this objective."

"We already know the basic structure of human DNA, so it is purely a matter of time before the map and sequence of human genes are produced--why not do it quickly?"

"Developments in automated technology and computers are now sufficiently advanced to allow the separation of the genome into its constituent parts. One field of science is inevitably driven by discoveries and inventions elsewhere."

"Science is value free. Scientists should be allowed to investigate anything--including the human genome. It is up to others to work out the implications. Science provides options, but individuals and society must choose among them."

"The project will bring prestige to scientists and their institutions, and consequently more funding for science as a whole."

"The project will heighten competition among scientists and their institutions and will lead to dishonesty. This could have dangerous consequences."

"Money spent on the human genome project should be spent on research into more important topics such as the environment."

"The human genome project will lead to an emphasis on gene structure rather than developmental genetics, which is scientifically more important."

"You can never predict the eventual outcome of scientific research."

Physician

"The human genome project will help us overcome the 4,000 or more human ailments that have a single-gene component."

"The project will help us to eradicate diseases that have a multi-gene component--such as cancer and heart disease--and enable people to live longer and healthier lives."

"The knowledge gained from the project will enable genetic screening to be carried out more effectively."

"The human genome project raises the possibility that a person's genotype will become public knowledge; this could undermine the physician's relationship of confidentiality with patients."

"The information from the project will be too general to have real benefit to medicine. It would be better to concentrate research on specific genetic ailments."

"More money should be spent on treating patients and on overcoming social and environmental causes of illness than on academic research such as the human genome project."

Industrialist

"If we don't undertake the project, other countries will--and gain the profits."

"The project will lead to developments of great economic value in the pharmaceutical and other industries and will provide employment for many people."

"There is the possibility of developing new technology and techniques that will reduce the cost of the project considerably."

"We need more time to think out the economic and other implications of the project."

"The money used in the project would be better spent on roads and other aspects of the economic infrastructure so as to support a wide range of industries."

"The results of the project should be made freely available to industry for economic exploitation."

"The government should own the patents to the knowledge about the genome (intellectual property) and regulate their use."

"Employers, insurance companies, or agencies of the state should have no rights to information about the genotypes of employees or clients."

Ethicist

"Human genome research will help us to understand ourselves and human nature more clearly, and enable us to behave more responsibly."

"Many human uses of genetic engineering resemble accepted forms of diagnosis and treatment that employ other techniques. The human genome project should provide thoughtful analysis, but should not be inhibitive."

"Morals change as understanding changes. Knowledge of the human genome will lead us to new moral criteria as acceptable as the ones we accept today."

"The problem is not to stop research on the human genome, but rather to educate the public."

"Science must take second place to our moral codes. We should first establish a moral code for dealing with the implications of human genome research before we embark on it."

"Any attempt to alter the natural state of human beings offends the integrity of human nature and should be resisted."

"Humans should not assume the prerogative of the Creator. No individual, group, or institution can claim authority to make decisions on behalf of the rest of the species; genetic engineering should be banned."

Source: McInerney, Joseph D. Teaching Biotechnology in Schools (Science and Technology Education Document Series No 39). Paris: Unesco 1990 pp 212-215.

- Project. Use of bar codes in the marketing of [food] products in supermarkets.

Question

Product bar codes like the one shown below now appear on many items stocked in supermarkets.

9 312345 678907

The first two digits (93) identify the country of origin as Australia; the next five digits (12345) identify the manufacturer; the next five digits (67890) uniquely identify the product by:

- type, flavour, etc.
- size of retail pack
- special or normal sale
- model or modification etc.

The last digit (7) provides an internal check of the information contained in the bar code.

The checkout assistant uses a scanner (most likely a laser beam code reader) which feeds electronic signals to a micro-computer to

- read the bar code
- retrieve the item description from memory
- send the price and description to the electronic cash register which provides a visual readout for the customer and prints the itemised docket tape.

The price of the item is entered by the retailer at the local store. The local store computer also maintains a continuous stocktake of items on the shelves and in the store and automatically re-orders products. The marketer of the product bar code system claims that its use is of benefit to the consumer, retailer, store employee and manufacturer. Others suggest there are both real and potential disadvantages to retail store employees and customers.

Write a brief argument in favour of (or against) the general introduction of product bar codes in retail stores.

In writing your answer you might consider:

- advantages and disadvantages to the customers
- advantages and disadvantages to the retail store employees
- advantages (or disadvantages) to the retailer
- ways in which the retailer can overcome the disadvantages to customers and store employees.

Source: Thomas, I.D. "Assessing Understanding of Science, Technology and Society Interactions in a Public Examination" in Waddington, D.J. Education, Industry and Technology (Science and Technology Education and Future Human Needs Volume 3). Oxford: Pergamon Press for the ICSU Press 1987 pp 199-209.

- Project. Trade patterns in biologically based products.

Choose two countries - one an advanced industrialized country and the other a less well developed country. From the library find out which products of biologically-based industries are traded between the two countries. Then answer the following questions.

(a) Which of the two countries has the most favourable balance of trade? Can you explain this?

(b) Choose one biologically-based product exported by each country to the other and for each describe how the application of biological principles could improve the quantity and quality of the product. Which of the two countries has put most effort into applying biological ideas in the improvement of its products? Can you explain this?

(c) Assume that the less well industrialized country wished to improve the quality of its biologically-based manufactured goods by seeking technical assistance from its more advanced trading partner. Briefly discuss the type of information and technical skills it would need to acquire from the other country.

Source: suggestion by author.

- Test Questions

(1) A dairy farm at Church Weston in Somerset is suffering from a cattle disease called 'staggers'. Scientists believe the disease is caused by a shortage of certain trace elements in the animals' diet.

To investigate the problem further, scientists analyzed the trace elements present in the livers of healthy and unhealthy animals. Their results are shown in this table. The figures show the concentration of each element in the livers, in parts per million (P.P.M.).

Trace Elements	Iron	Nickel	Copper	Zinc	Chromium
Healthy Animals	180.0	4.0	70.0	4.0	2.0
Unhealthy Animals	212.5	3.4	18.0	5.4	1.1

(a) What is meant by a 'trace element'?

(b) Using the figures in the table, suggest which element is most likely to be responsible for the disease. Give a reason for your answer.

(c) What other tests would you do to try and confirm your answer to (b)?

(d) Explain why a shortage of a particular element in the soil can lead to a shortage of the same element in an animal's body.

(e) What steps could the farmer at Church Weston take to try and stop the disease?

(f) Iron is an important trace element. Name one important use of iron in mammals.

(g) What disease in humans results from a shortage of iron in the diet?

Source: Pritchard, Alan P. Biology and Human Welfare Case Studies in Teaching Applied Biology (Science and Technology Education Document Series No 25). Paris: Unesco 1988 pp 59-60.

(2) Under each of the following areas list down new studies in biotechnology that contribute to the improvement of human life.

(a) Growing better crops
(b) Raising better livestock
(c) Alternative foods
(d) Disease control
(e) Alternative sources of fuel

Source: Philippines Ministry of Education, Culture and Sports (MECS) "Biotechnology: Its Place in the Home, Community and the Country" in Science and Technology II Revised Edition manuscript. Manila: MECS 1989 pp 8-22.

(3) Write an essay on the transfer of biological technologies from developed industrialized countries to underdeveloped countries. In particular comment on the following aspects.

(a) The priorities of capital intensive versus labour-intensive technology

(b) The rights of licenser and licensee

(c) The transfer of "dirty" or obsolete technology

(d) Ways of overcoming low technology development within a short time.

Source: Based on Frazer, M.J. and Kornhauser, A. "Ethics and Social Responsibility in Science Education: an overview" in Frazer, M.J. and Kornhauser, A. (Eds) Ethics and Social Responsibility in Science Education (Science and Technology Education and Future Human Needs Volume 2). Oxford: Pergamon Press for the ICSU Press 1986 p 35.

(4) "The Third World is obviously a fertile market for the new products of biotechnology. Therefore Third World nations must have the capability to assess these technologies as they are slowly being moved into their markets. What kinds of conditions are necessary for the Third World to take advantage of the benefits of each of the following aspects of biotechnology. [Write about one page on each aspect.]

(a) cell fusion
(b) genetic engineering
(c) monoclonal antibodies
(d) cell and tissue culture

Source: based on an extract from Padolina, William G. "Biotechnology and its Implications for Biology Teaching in Developing Countries" in Unesco: New Trends in Biology Teaching Volume V. Paris: Unesco 1987 pp 116-133.

(5) "Almost all technological changes in the past have had positive and negative effects on society". Choose any one biological technology and list down some of its positive and negative societal effects.

Source of quotation: Modified from Harrison, A.J. "Roles of Scientists, Engineers and the Public in the Resolution of Societal Issues" in Fraser, M. and Kornhauser, A.

(Eds) Ethics and Social Responsibility in Science Education (Science and Technology Education and Future Human Needs Volume 2). Oxford: Pergamon Press for the ICSU Press) 1986 pp 37-41.

8.4 Environmental Management

i) Rationale

Unlike environmental awareness issues which are an immediate concern of the community at large (Chapter 7), issues of environmental management have a strong future orientation. Effective environmental management is of course based on environmental awareness but involves careful forward planning.

Effective environmental management involves understanding and applying the principles and techniques of systems analysis, population dynamics and the concepts of carrying capacity to ensure both ecologically and socially sustainable development.

Issues in environmental management within a course of socially oriented biology must of course be based on the science of biology. Areas of the curriculum especially relevant include ecosystem analysis; the effects of pollutants on humans and on animal and plant communities; the exploitation of renewable resources (see section 8.5); biogeochemical cycles; population studies; the conservation of diversity; land use, and those agricultural, commercial and industrial developments involving the application of biological principles.

Management problems are of course wide ranging and may be at local, national and international levels. At the local level a community should be concerned with issues such as effective town planning, the reduction of pollution, aesthetics of the environment, the establishment and management of parks, zoological gardens and similar facilities to name just a few. National environmental management issues that could be addressed include issues such as balancing the needs of economic development against those of conserving the natural environment, the establishment of game parks and other forms of "natural" parklands, techniques for ensuring balanced developments in agriculture and industry, and programmes for ensuring a healthy and positive life style for all based on the principles of sustainable development. Internationally there are many management issues of concern to all peoples of the world. These include atmospheric pollution and the greenhouse effect; the problem of acid rain; population and immigration issues; the balanced exploitation of resources; protection of fragile ecosystems such as the Arctic and Antarctic regions and the rainforests of the world; combating desertification and so on.

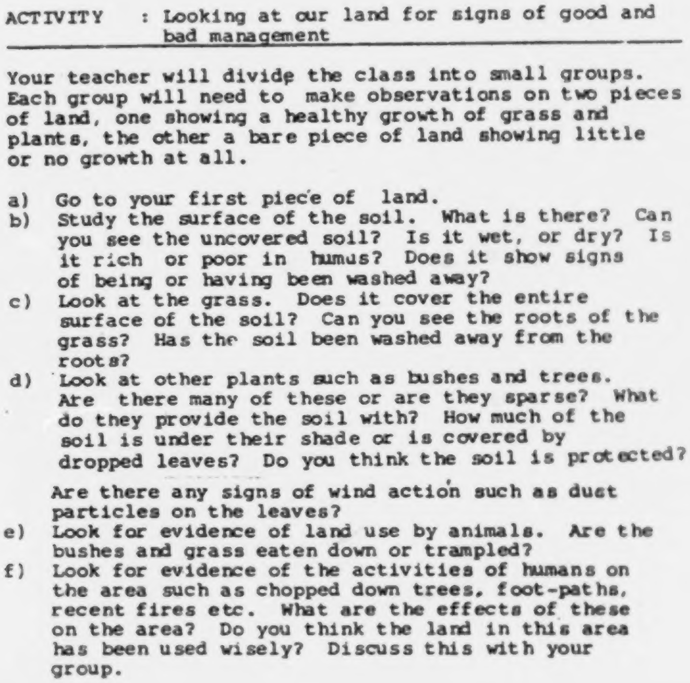
Once again, therefore, an issues approach is advocated and students should be encouraged in critical thinking and the solving of problems including observation; data collection; analysis and synthesis of data; and evaluative decision making. They should not be discouraged from facing up to situations and issues involving conflict but should become skilled in the techniques of values clarification and conflict resolution.

Studies of environmental management should be strongly future oriented and case studies should be selected which are of real concern to the learners. Every opportunity should be taken to ensure that transfer occurs from the specific case studies selected to the long term management of wide ranging environmental issues at local, national and international levels.

iii) Examples of Content

Example 8.11: Management of land quality in agricultural regions

School System: Zimbabwe secondary school biology
Approach: Observations and experiments involving analysis of ground cover and soil erosion
Source: Ministry of Education Zimbabwe Science in Agriculture Module 1 The Soil 'O' Level Study Guide (Zimbabwe Secondary School Science Programme) Harare: Ministry of Education Curriculum Development Unit 1986 pp 46-50.



ACTIVITY : Looking at our land for signs of good and bad management

Your teacher will divide the class into small groups. Each group will need to make observations on two pieces of land, one showing a healthy growth of grass and plants, the other a bare piece of land showing little or no growth at all.

a) Go to your first piece of land.
b) Study the surface of the soil. What is there? Can you see the uncovered soil? Is it wet, or dry? Is it rich or poor in humus? Does it show signs of being or having been washed away?
c) Look at the grass. Does it cover the entire surface of the soil? Can you see the roots of the grass? Has the soil been washed away from the roots?
d) Look at other plants such as bushes and trees. Are there many of these or are they sparse? What do they provide the soil with? How much of the soil is under their shade or is covered by dropped leaves? Do you think the soil is protected?

Are there any signs of wind action such as dust particles on the leaves?

e) Look for evidence of land use by animals. Are the bushes and grass eaten down or trampled?
f) Look for evidence of the activities of humans on the area such as chopped down trees, foot-paths, recent fires etc. What are the effects of these on the area? Do you think the land in this area has been used wisely? Discuss this with your group.

g) Record all the observations you made.
h) Go to your second piece of land and repeat the steps (b) to (g) .
i) When you have completed recording all the observations on your second piece of land go back to your classroom and draw up a table in your notebook to show a summary of the main similarities and differences between the two pieces of land.

Your teacher will help you to draw up this table.

GROUND COVER

You many have concluded that one of the main differences between your two pieces of land has something to do with what scientists call GROUND COVER. This refers to all the materials that are found covering the surface of the soil such as live or dead plants, animal droppings etc. What is the importance of ground cover?
Let us try to find out about this in the next experiment.

EXPERIMENT 1 : Finding out about the effects of ground cover.

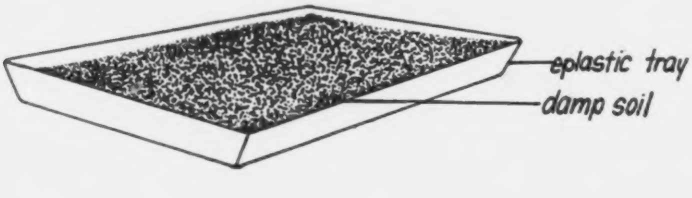
You will need :

3 plastic trays filled with damp soil (1 containing growing millet seedlings).
12 small flat stones
4 handfuls of dried grass or leaves
1 watering can or tin can with holes made at its bottom
1 empty plastic tray
1 bucket of water
4 large boiling tins or similar containers.
an empty match box.

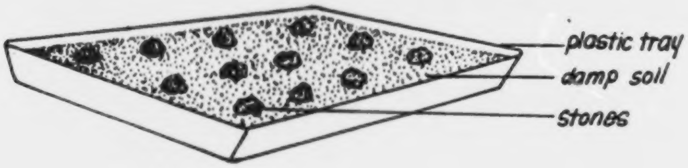
a) Copy down the table below into your notebooks.

TRAY	SPEED OF RUN-OFF WATER	COLOUR OF WATER COLLECTED	AMOUNT WATER COLLECTED	AMOUNT SOIL COLLECTED	APPEARANCE OF SOIL SURFACE
TRAY 1					
TRAY 2					
TRAY 3					
TRAY 4					

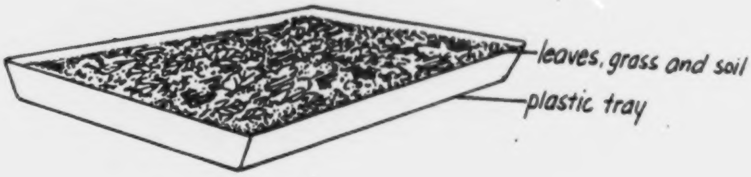
Tray 1 to contain damp soil only



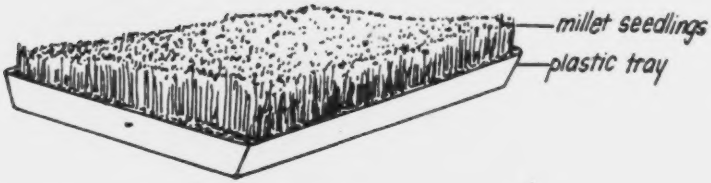
Tray 2 to contain damp soil with stones placed at intervals all over the soil surface.


plastic tray
damp soil
stones

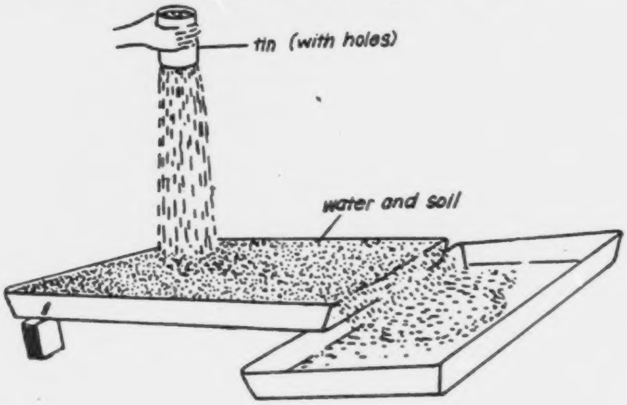
Tray 3 to contain damp soil with dried plant materials such as grass or leaves


leaves, grass and soil
plastic tray

Tray 4 to contain a thich growth of millet seedlings about 3 cm in height.


millet seedlings
plastic tray

b) Take your trays outside and continue as follows: Place an empty tray under one end of Tray 1 and a match box under the other end so that Tray 1 is in slopping position. Holding a watering can or a perforated tin can about ½ a metre above the tray, pour 500 ml of water over the whole surface of Tray 1 as shown in the diagram below.


tin (with holes)
water and soil

This imitates the action of rain. The water and the soil running off will be collected in the receiving empty tray as you pour the water. Note how quickly the water runs off from the tray. When the water has stopped draining, pour it from the tray into a large boiling tin or a similar container.

c) Repeat the same procedure with Trays 2, 3 and 4 and record all the information you need to fill in the table in your notebook.

d) From which of your trays was the speed of run-off water (i) fastest and (ii) slowest?

e) Look at the colour of the water collected as run-off from each tray and describe it as very dirty, least dirty, clearest.

f) Using a measuring cylinder measure the amount of water collected from each tray.

g) Estimate the amount of soil collected by run-off water from each amount.

h) Describe the appearance of the soil surface in each tray using the terms well-eroded, eroded, slightly eroded.

i) On the basis of your observations and the results you filled in the table in your notebook draw up your conclusions and describe the effects of ground cover on your soil sample and on agriculture in general

Example 8.12: Environmental management from an historical perspective

School System: -

Approach: *Historical analysis of changing patterns of environmental management through a library research project and discussion*

Source: *Meadows, Donella H. Harvesting One Hundredfold Key Concepts as Case Studies in Environmental Education. Nairobi: United Nations Environment Programme 1989 p 37.*

EXAMPLE:* *Sampling Human History

Get two bowls from which students can draw slips of paper. Fill one bown with slips on which are marked historical dates, beginning about 4000 B.C. and going in 100-year increments to the present. Fill the other bowl with slips on which are written the present names of the countries of the world. Ask the students to work in groups of two or three; ask each group to choose one slip from each bowl. One group might end up with Thailand, 500 B.C., for instance; another might draw Colombia, 1400 A.D. or Poland, 400 A.D.

Ask each group to go to the library and learn all they can about the country they have drawn at the time they have drawn. Suggest that they consult not only history books, but books of anthropology, natural history, climatology, geology. The students may have trouble finding anything about their designated place and time; encourage them to speculate from whatever information they can find, and to label their speculations clearly, to indicate their degree of uncertainty, and to describe what information led to them—that is, conduct a small lesson in drawing conclusions with integrity from insufficient information.

Ask each group to prepare both a written and an oral report describing what the landscape was like, what natural ecosystems were there, what the peoples' lives were like, what technologies they used, what kinds of government and religion they had, what historical events, if any, took place.

All the reports together will add up to an impression of human history quite different from the impression one gets from history books alone. With this truly random sampling through time and space, students are unlikely to draw a place for a century in which "historic events" were happening. Most of human history has in fact been "uneventful" and unrecorded. Life has been simple and strenuous and relatively peaceful. Cultures have evolved very slowly, civilizations have risen and fallen. National boundaries and place names were generally different from the present ones, and ecosystems were often very different. There is a very low probability that any group will draw an assignment that covers any country in the industrial age.

Let all these points come out in the discussion. Go on to discuss the reasons why civilizations rise and fall, the interactions of those civilizations with their environments, the slow adjustment times of cultures and social mechanisms, the different rates of change of ecosystems, social organizations, individual human

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beings, and technologies. Ask the students to comment on the accuracy of aphorisms such as, "Forests precede civilization; deserts follow," and "He who does not understand history is destined to repeat it." Ask the students what the term "sustainable development" might mean, whether it is possible, what it would take to attain it.

* * *

Because of its *problem orientation* and orientation toward *whole systems,* environmental education is naturally and easily *interdisciplinary.* Real problems and real investigations of the holistic nature of the world almost never can be confined neatly to one discipline. Environmental education uses the *resources at hand,* including the school itself, the school grounds, the community. It often involves *activity in groups,* group discussion, drawing good ideas from the group, both because group activity illustrates the key concept of development through peoples' participation, and because it is useful to give students training in teamwork—so many activities in life require group skills. Environmental education also includes open acknowledgement and discussion of *values and ethics,* especially the relation between human beings and nature.

In short, the methods and tools of environmental education are:

- participatory and experimental,
- problem-oriented,
- interdisciplinary,
- integrated into the nearby surroundings,
- group-oriented,
- value-based.

There are not characteristics that are common to formal education in many countries, and many teachers have not been trained in, have not even experienced, such education. Yet all over the world teachers are pioneering, using the simple and natural technique of choosing an interesting, nearby problem and following wherever it leads, often learning right along with the students. When that happens, when the teacher is learning too, an extremely powerful thing happens. The students are not only learning about acid rain or desertification or the preservation of endangered species, or whatever the particular content of the lesson is, they are also *learning how to learn.* By watching the teacher's own curiosity and resourcefulness in solving a problem, by seeing how the teacher asks questions, confronts new information and overcomes obstacles, they are picking up tools for learning that will last them all their lives and will guide them in their own self-indusced, *lifelong* environmental education.

Example 8.13: Game park management

School System: Zimbabwe secondary school biology
Approach: Simulated case study of a management issue in an African game park
Source: Parker, Sylvia Studies in School Ecology. Harare: University of Zimbabwe Science Education Centre 1974 pp 62-63.

THE PROBLEM OF THE STRICKEN GAME PARK (see Fig. 1.35)

This desperate area of 8 000 hectares has been declared a small wild life area and has come under the control of the wild life authority. You as game warden have been given the job of taking over the badly deteriorated veld where numerous animal populations have converged due to surrounding farming pressure and drought conditions. Your task is to immediately implement changes that will bring about veld rehabilitation. Your aim is a correct balance between the animals and vegetation.

Indicate on the map and in the space provided for comments, at least six measures you would take. You have been assigned a sum of money and a labour force to do this.

Animals present in game park: elephant 20, square lipped rhino 6, zebra 100, giraffe 45, eland 100, wildebeeste 200, sable 50, impala 200, crocodile 2, serval 2, civet 1, leopard 1.

Note: One elephant needs approximately 400 hectares of veld. (By way of interest, one person needs approximately 0,4 hectares of arable land - "The limits to growth").

By contrast some figures for Robert McIlwaine Game Park near Salisbury (1973). Area of Park: 2 600 hectares. Animals present in Game Park: square lipped rhino 4, zebra 28, tsessebe 22, giraffe 3, eland 18, sable 36, wildebeeste 60, waterbuck 40, impala 50, reedbuck 4, ostrich 36, serval 1, civet 1.

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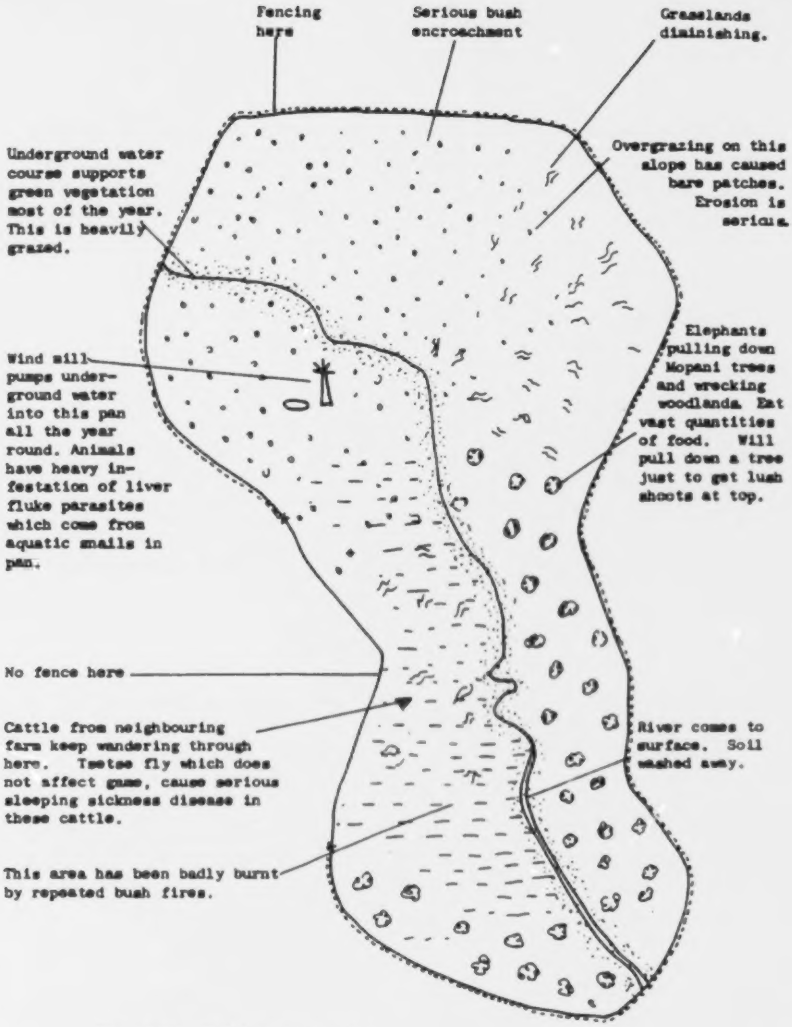
Fencing here
Serious bush encroachment
Grasslands diminishing.
Underground water course supports green vegetation most of the year. This is heavily grazed.
Overgrazing on this slope has caused bare patches. Erosion is serious.
Wind mill pumps underground water into this pan all the year round. Animals have heavy infestation of liver fluke parasites which come from aquatic snails in pan.
Elephants pulling down Mopani trees and wrecking woodlands. Eat vast quantities of food. Will pull down a tree just to get lush shoots at top.
No fence here
Cattle from neighbouring farm keep wandering through here. Tsetse fly which does not affect game, cause serious sleeping sickness disease in these cattle.
River comes to surface. Soil washed away.
This area has been badly burnt by repeated bush fires.

Fig. 1.35 Stricken game park.

Example 8.14: National environmental planning

School System: Federal Republic of Germany secondary schools
Approach: Description of a simulation game
Source: Vester, F. "Polit-Spiel Okolopoly". Natur; Horst Sterns Umweltmagazin (Munich) 0 - Number 1981 in pp 115-122, cited in Lehmann, Jürgen and Schilke, Karl "Games and Simulations in Biology Teaching" in Unesco: New Trends in Biology Teaching Volume V. Paris: Unesco 1987 pp 75-101.

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There are a variety of simulations for biology instruction in which students assume the roles of politicians, industrialists, technicians or farmers. These roles differ from the researcher role in that they are geared less to knowledge and more to changes in the natural environment. An example is the game 'Pollution' in which every player owns a few public or private firms. These firms cause varying levels of pollution, and as it costs money to reduce the levels, the players try to find a strategy which increases their own profit without sending the level of water and air pollution into the critical zone.

A game developed fairly recently by Frederic Vester (1981) will now be described in more detail. 'Ecolopoly' simulates a journey through Cybernatia, a country in which there are eight areas of interest: redevelopment, production, pollution, quality of life, enlightenment, rate of population growth, population structure and politics. These are represented on a printed plan of the country (Fig. 3).

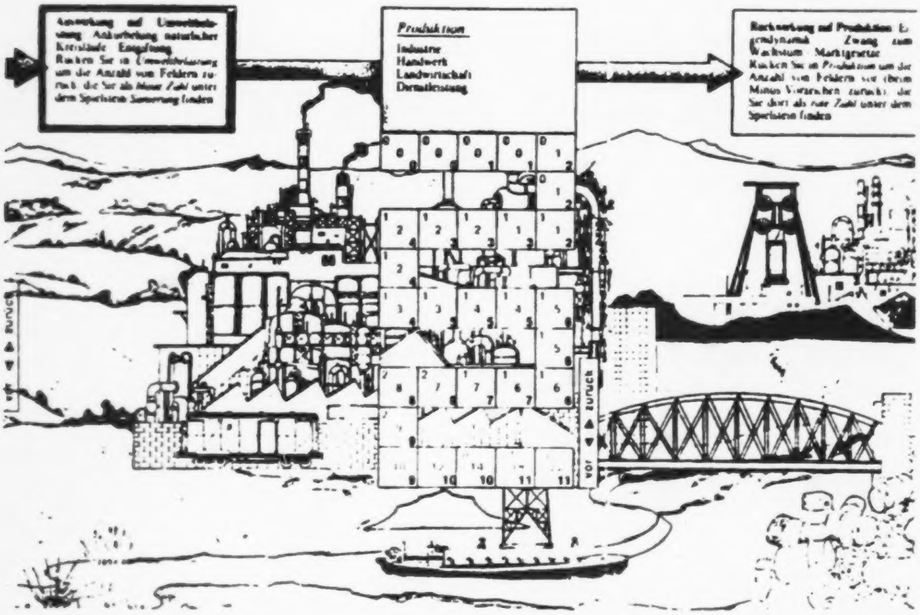


Fig. 3. A detail of the format for the simulation game 'Ecolopoly' (F. Vester, 1981). *Left:* effects of pollution; *centre:* production; *right:* repercussions for production.

The aim is to improve the quality of life. To this end the players can invest 'action points' in five areas, i.e. they can place counters in the areas of redevelopment, production, quality of life, enlightenment and rate of population growth. These moves reflect investment or reduction in the respective areas. Instructions which the players must follow are provided on the plan of Cybernatia. It is possible for one set of instructions to change all counters in all areas. The game is therefore conducted in rounds. The players try to act in different areas to improve the quality of life, although initially they meet with little success.

The game ends after a previously agreed number of rounds. The players then consult a key to discover from their point score how good they have been as administrators of Cybernatia.

The game is intended for individual players, each of whom must have a copy of the printed plan of Cybernatia. The maximum number of players is thus determined by the number of available plans. At the end of the game the players compare their scores.

Example 8.15: Alternative land use - marginal farming land

School System: Zimbabwe secondary school science
Approach: Simulated case study of alternative ways of using land and the determination of management policy
Source: Ministry of Education Zimbabwe Science in Agriculture Module 4 Conservation ('O' Level Study Guide) (Zimbabwe Secondary School Science Programme). Harare: Ministry of Education Curriculum Development Unit 1986 pp 27-29.

CASE STUDY OF A MARGINAL AREA

Read through this case study and discuss it with your teacher.

An area of 5000 ha near Mwenezi in the Southern part of Zimbabwe is to be resettled. The land is in region 5 of the country where rainfall is less than 500mm per year and is erratic. It is risky to grow even drought resistant crops. Temperatures are well above 25°C in hot weather. The soil is usually dry. Irrigation systems are not possible. This means the area is on the edge or margin of being agricuturally productive in terms of crops. The government wants to settle ten families in the area. It also wants to practice good conservation. It wants to use the area in the wisest possible way so that land and vagetation do not deteriorate.

The governement has two choices:

CHOICE A : TEN FARMS EACH OF 500 ha

Farmers say they would like to grow crops, rear cattle and goats. They have been advised that in this lowveld area one livestock unit (L.S.U.), such as an ox, needs 20 ha of land to graze. This is bacause suitable vegetaion is not plentiful. Grass cover is not good. In some places the ground is bare. When rains come good annual grasses grow. Cattle do well on these. However, when the rainy season is short, annual grasses die off. They must grow from seed again the following year. Grazing is scarce during the long dry months. This marginal area is subject to drought. Perhaps only once in every five years are the rains reasonable. Mopani trees are plentiful in the area together with bush and Acacia thorn trees. Cattle are able to eat Mopani leaves when grass is scarce. This helps cattle to survive but does not keep them in top condition. Goats eat almost any form of vegetation within goat-reaching height.

CHOICE B : A GAME RANCH OF 500 ha.

An alternative way of using the land would be to keep the area as one unit and ranch game. Elands, impalas, lions, giraffes, bushbucks and leopards are already in the area. Their numbers could be build up if they were left to breed naturally. Perhaps elephats could be brought into the area too. Game animals are able to eat many kinds of vegetation. Eland impala and giraffe, for example, browse (feed on tree leaves). Game animals usually manage on less water than cattle. Water is available at pools in places along the otherwise dry river bed. Game animals can be sold live. However, being wild they are difficult to catch and handle. Sometimes helicopters are used to herd them into a 'boma'. This is a sort of kraal with walls made of plastic sheeting.

The meat of game animals can be sold or made into biltong. The skins of game animals also fetch good prices if properly cured.

The ranch could also be used for hunting safaris. Wealthy tourists from abroad will pay large sums of money to hunt with guns in the area. Prices for shooting a particular type of animal are laid down by government. For example, a person must pay $250 to shoot and kill one buffalo. The number of game shot must also be strictly controlled. These wealthy hunters insist on staying on beautiful camps set up for them. They need vehicles, trackers, guides and domestic workers.

Write down in full your answers to the questions below.

CHOICE A : TEN FARMS EACH OF 500 ha

1. Give an example of a dryland crop that could be grown in the area?
2. Why would crops not be successful every year ?
3. State one advantage of rearing cattle in the area.
4. State one disadvantage of rearing goats in the area.
5. Why would clearing the land of trees in the hope of growing more grass not be wise ?
6. How many cattle could the vegetation properly support on one farm?
7. Would this number of cattle support a family of eight people?
8. What would be an advantage of introducing rotational grazing?
9. What would be a disadvantage of introducing rotational grazing?
10. Why would it be unwise to burn the area every year in order to produce green grass?

CHOICE B : ONE GAME RANCH OF 500 ha

1. Why would game animals make better use of the vegetation than cattle and goats?
2. Game animals mostly need water less frequently than cattle. Why would this be an advantage.
3. Would game animals need fences?
4. How could game animals shot and killed in the wild be used?

5. Would game animals be less likely to become sick and diseased?

6. Does the carrying away of dead game animals shot and killed in the wild pose problems?

7. If safari hunting were introduced in the area, how could safety be maintained?

8. Why would burning one quarter of the area every four years be useful?

9. How could the numbers of wild animals be maintained so that populations do not decrease?

10. How would you make sure that wealthy tourists were satisfied with the services offered?

SUMMARY

1. Management of ecosystems will depend on the understanding of the principles upon which ecosystems function.

2. Improvement of ecosystems involve taking measures to ensure rentention of water in the soils, presence of ground cover on the soil surface, prevention of over-grazing and maintenance of soil fertility.

3. Rational utilization of resources means carefully selecting suitable areas for growing crops, rearing animals, and keeping suitable indigenous plants and animal populations in marginal areas.

Example 8.16: Alternative land use - a bog (swamp)

School System: Finland secondary schools
Approach: Role play of meeting of land owners to recommend policy in regard to using swampland
Source: Professor Ilta Kankaanrinta: Department of Education, University of Helsinki. Helsinki 1989 Personal communication.

What shall we do to the bog of Käpäläräme?

This role game was made by three school girls, aged 13, in the comprehensive school. They made the play quite on the terms of their own. It was played by them for hours and they found it very funny.

The technical compositon is quite simple. There is a plan of the bog with the boarders of different land owners. The character of the owner, it is the role of the player is described on the plan, too.

There are six persons, each of which owns a piece of bog. These pieces border upon a bigger area of the bog owned by the state. The bog could be drained and so the trees would grow better. This way the bog would became more valuable. But some of the present owners will have the bog as it is for the moment, because it is a nice place to walk around and collect berries like cloudberris (Rubus chamaemorus), cranberries (Vaccinium oxycoccos), red whortleberries (Vaccinium vitis-idaea) and bilberries (Vaccinium myrtillus). The landowners meet and discuss of the sale of their lands to the state.

Eino Pyy ("Hazel hen"), painter, 23 years.
Is a professional artist. Paints the life on the bog. Lack of many very often. Lives together with a lady painter, one baby. Is against the sale of the bog.

Miss Hilda Sjöberg, bank official, retired, 60 years.
A widow, no children. A little money in the bank. Has got her piece of the bog as an inheritance. Wants to sell her land.

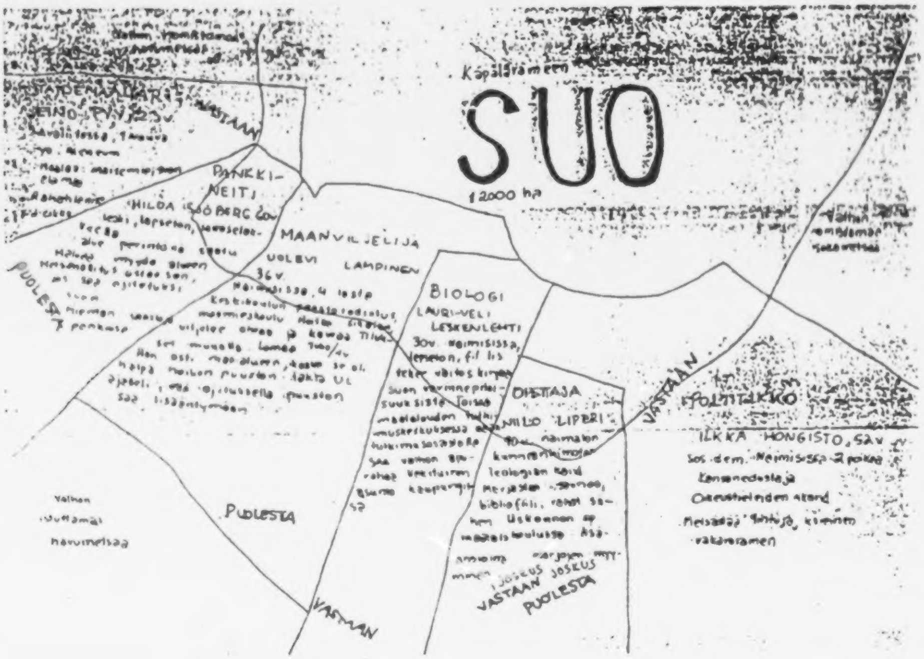
Uolevi Lampinen, farmer, 36 years.
Married, four children. Studies in comprehensive school and a vocational farmer education. Has a big pigsty, grows barley and oats for the pigs. Uolevi Lampinen has bought his bog because it was cheap. Wants to sell it.

Lauri-Veli Leskenlehti, biologist, 30 years.
Married, no children. Makes thesis on the nutrients of the bog. Working in the Institute for Agriculture Research, Department of the Soil. Has a grant from the state. Lives in the city. Against the drainage and the sale.

Niilo Liperi, teacher, 40 years.
Single theologist without a least ambition. Bibliophile: loves and collects books and spends all his slight money in that. Teaches religion in a little school in the countryside. Picks beries on the bog and sells them. Has a passion to sauna baths. Sometimes against the sale, sometimes for it.

Ilkka Hongisto, politician, 52 years.
Labour party, married, to sons. Member of the Parliament, layer. Hunts birds, solid, busy. Against the sale.

In this play the most important is the process of discussion, not the result. The players have to propose their opinions and to listen to the others. They have to defend their opinions and to make compromisses. The process on decision making becomes concrete to them.


Kapalarameen
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OPETTAJA
NIILO LIPERI
POLIITIKKO
ILKKA HONGISTO, SAV
VASTAAN
PUOLESTA
JOSKUS VASTAAN
JOSKUS PUOLESTA

Kapalarameen suo -roolipelin pelilauta.

Example 8.17: Planning to build a zoological park

School System: *Canada Ontario and British Columbian secondary school systems*
Approach: *Values clarification to determine a local environmental management issue*
Source: *Association for Values Education and Research University of British Columbia Ecology Teacher's Manual. Toronto: The Ontario Institute for Studies in Education 1980 pp 25-26.*

THE ECOLOGICAL PERSPECTIVE

Objectives
Students will be able to:

- define and give examples made from the ecological perspective
- synthesize and apply all the value reasoning skills

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Procedure

1. Students could read "The Ecological Perspective" and be asked to define the ecological perspective. Whereas the ecological perspective is essentially scientific, how do value judgments relate to it? Bob Hunter's article could be used to answer the questions provided, and to help students become clearer about the ecological perspective (Activity XIII).

2. The ecological and other points of view could be represented in a Reasons Assembly Chart on the issue of "Building a Zoological Park" using the two articles provided.

Building a Zoological Park

Positive		**Negative**	
Underlying Value Principle	**Factual Premise**	**Factual Premise**	**Underlying Value Principle**
It is valuable to prevent the extinction of animals	Building a zoological park will prevent the extinction of animals	Building a zoological park will prevent money from being used for the care of people	We should not spend money on animals which will prevent money from being used for the care of people
Animals ought to have the right to a natural environment	A zoological park will provide a natural environment and breeding ground for endangered animals	Building a zoological park will not stimulate the economy	We should avoid doing that which will not stimulate the economy
All ecosystems should should be balanced	Building a zoological park will aid in maintaining the balance of the ecosystem	Building a zoological park will waste valuable land	Valuable land should not be wasted
Therefore, we should build a zoological park		Therefore, we should not build a zoological park	

(a) Factual and value claim distinctions could be reviewed.

(b) Students could identify the points of view used in each argument.

Positive:	*Negative:*
1. Ecological	1. Moral or Economic
2. Ecological	2. Economic
3. Ecological	3. Economic

(c) Value principles could be tested. Examples:

Role Exchange:
How would you feel if you were one of the people who had to vacate your home to provide the land for the zoo?

Universal Consequences:
What would happen if *no* cities decided to spend money on preventing the extinction of animals?

New Cases:
Broad moral principle – "We should protect endangered animals."

3. The worldwide implications of using the ecological perspective could be researched. Questions could be posed such as:

-Do ecological problems in other countries affect us?
-Should we do anything about problems in other countries? Why or why not?
-Can we do anything about problems in other countries?
-Are there any ecologically sensitive areas in your geographical area?
-Are they being disturbed?
-What would happen if economic development always took top priority and resulted in the destruction of a particular ecosystem?

4. As culminating activities, the following could be carried out:

(a) Research environmental control services or societies. Conclude as to whether these organizations are doing too much or too little and be able to state reasons for the conclusion. See "An Interview with an Official of the BC Department of the Environment, Summer, 1978."

(b) Explore an ecosystem (lake or pond) and explain how the various life forms are interrelated. State how this ecosystem could be (or is being) damaged, and what could and should be done about it.

(c) Photograph aspects of pollution and set up a display.

(d) Play one of the simulation games noted in the bibliography.

(e) Carry out a recycling project.

(f) Discuss one or more of the dilemmas presented in Activity XIII. Subject the value principles to principle testing methods.

(g) Debate topics such as:

Do animals have any rights?
Are we responsible for pollution?
Should smoking in public places be prohibited?
Does it matter if certain species become extinct?

Note: For an account of the "ecological perspective" mentioned in the above example see Balch, I.R.E. The Ecological Point of View. Toronto: CBC Learning Systems 1965 p 11.

Example 8.18: Town planning and environmental management

School System: United States secondary school science
Approach: Simulated case study of a town planning activity to ensure effective environmental management
Source: Biological Sciences Curriculum Study (BSCS) Investigating the Human Environment Land Use. Colorado Springs: BSCS 1984 pp 82-85.

Background Information:

Activity

E. Sudnal is a fictitious city located somewhere in the United States (Figure 37). It is a growing city. E. Sudnal has just annexed two square miles of land. Each of you will represent an interest group in the city that wants to use the land in a different way. First as individuals and then as a group, you will decide how the land just annexed by E. Sudnal will be used. The land is owned by the city, but it may be sold or used for any purpose that the city wishes.

There are ten interest groups involved in this simulation. Speaking for some of those groups are a farmer, a college student, a single parent, a retired citizen, and an industrialist. Other groups are represented by a real estate broker, an environmentalist, a construction worker, a restaurant owner, and a city manager.

Refer to the map in Figure 38. The lake on the annexed land is unpolluted and is one source of irrigation and drinking water for the city. The present sewage treatment plant and sewer lines of E. Sudnal are working at their top capacity. And the garbage dump is only large enough to handle garbage from the current population.

The population of the city is 100,000. The growth rate during the last ten years was 25 percent. How many people were added to the city's population each year? Projections for the future show a similar growth rate for the next ten years. The birthrate of the city is 20 births per 1,000 people per year. The present age structure of the community is shown in Figure 39.

Per capita income for the city is $11,000. There are about 40,000 jobs in the city. The unemployment rate is six percent, that is, 6,000 people of working age need jobs. The income distribution of the city is shown in Figure 40.

There are 24 elementary schools, each of which can accommodate up to 500 students. Each of the 13 junior high schools can serve 750 students. Five high schools have room for 2,000 students each.

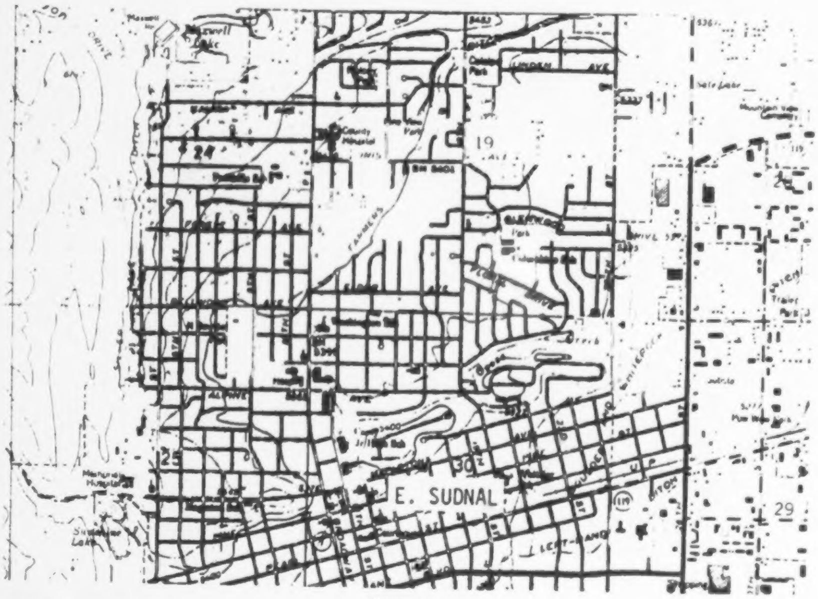

Figure 37.

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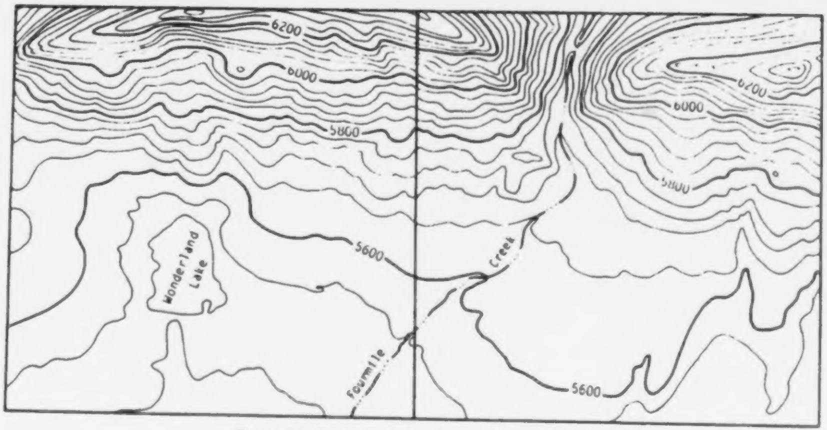

Figure 38. Two square miles annexed by E. Sudnal

Age	Number
Under 5	14,000
5-9	12,000
10-14	10,000
15-19	11,000
20-24	10,000
25-34	13,000
35-44	8,000
45-65	15,000
Over 65	7,000

Figure 39. Age structure of the population of E. Sudnal

Annual Income	% of Population
Less than $5,000	20
$5,000-$8,000	12
$8,000-$12,000	22
$12,000-$15,000	18
$15,000-$18,000	11
More than $18,000	17

Figure 40. Income distribution of the population of E. Sudnal

Activity:

1. Your class will be divided into groups of ten students each, and a set of role cards will be distributed to each group.
2. Each member of the group will select a card at random. Read about the individual described on your card. Take particular notice of the proposed land use this individual wants. Try to think of arguments and consequences that will persuade the others in the group to support your cause.

   The total amount of land needed for each use is shown on the card. However, the total area of all the proposed land uses is much greater than the 1,280 acres available for development (Figure 41). This means that some proposed land uses cannot be accommodated or some of the proposed land uses will have to be reduced in size.
3. Obtain Worksheet 16 for E. Sudnal. List the positive consequences of your proposed land use. What good things would come about if your proposal were accepted? Some things to consider are listed in Figure 42. Choose five that you feel are most important and most persuasive.
4. As soon as all the people in your group have written down their five most persuasive arguments, begin a group discussion of the proposals and consequences. Select someone to begin, and then follow in a circle until all have spoken. When it is your turn, tell the group who you are, what your proposed land use is, and how much land it will take. Then, give the group your five positive consequences. Be very convincing.

Proposed Land Use	Amount of Land Needed (acres)
Shoe manufacturing plant	40
Low-cost housing	40
Dump and sewage treatment plant	10
Luxury homes	640
Park	320
Shopping center	40
Open space	1,280
School	20
Houses and condominiums	240
Farm	240
Total	2,870
Total land available	1,280

Figure 41.

Will the Proposed Land Use Have an Effect on Individuals?

1. Will it change individual life-styles? Will it cause people to live in different ways? Will it allow them to do something that they want to do? Will it force people to do something that they do not want to do, or to stop doing something they currently do?
2. Will it change individual financial situations? How will the proposed land use be financed? Will it affect the cost of goods and services? Will it affect taxes? Will the action affect people's jobs—create new jobs or eliminate current jobs?
3. Will it change the health of individuals? Will the land use have a foreseeable positive or negative effect on the physical or mental health of individuals in the area? For example, will it disrupt the social structure of a neighborhood?

What Are the Consequences for the Whole Community?

1. Will the action conflict with the land's current economic (agricultural, mining, industrial) use or recreation use? Will the action conflict with the land's aesthetic value?
2. Is the land especially well-suited for one use and less appropriate for other uses?
3. Can the local government provide necessary services: water, sewers, electrical and gas connections, waste disposal, transportation, police and fire protection, and schools?
4. What about conflicting interests? Will the action satisfy the wants or needs of only a small part of the community's population?

How Will Various Parts of the Natural Environment Be Affected?

1. Does the area have unique geological, biological, archeological, or historical features that should be preserved?
2. What effect will the action have on vegetation, wildlife, and wildlife habitats?
3. What effect will the action have on temperature, climate, or air quality?
4. What effect will the action have on water quality?
5. Are there natural hazards in the area that should be considered? These may include floods, types of soil, erosion, landslides or snow avalanches, sinking or settling of the earth, earthquakes, and high winds or other dangers due to extreme weather.

Figure 42.

5. As each person speaks, the other group members will write down that person's occupation, the use of land he or she is proposing, and the positive consequences that the citizen gives.
6. As soon as all ten people have presented the positive consequences of their proposed land uses, take a few minutes and evaluate each of their statements. Use the evaluation technique you used earlier in this book (page 12). Assign only positive scores to these consequences. Give the consequence a 0 if you feel it is of no value. Give it a +10 rating if you believe it to be very important and very good. Of course, you may use any numbers between 0 and 10. Do not evaluate your own arguments.
7. Total all of your evaluation sheets. Compare your evaluations with those of others in the group. Citizens who have similar opinions and values concerning the use of the annexed land should get together in small groups. If you feel that you have nothing in common with the rest of the citizens, you may continue to act as an individual.
8. These small groups or individuals should now begin to think of negative consequences of all the land use proposals they are against.
9. Discuss the proposals again. This time each person will express his or her *opposition* to a proposal and then give five persuasive *negative* consequences.
10. All others in the group will write down these negative consequences. As soon as everyone has spoken, take a few minutes to evaluate each of the statements. A −10 rating indicates you believe the consequence listed is very bad. Assign only negative scores to this second set of arguments. Total them for each proposed land use.
11. Add your negative evaluation score to the positive evaluation score for each land use. Compare them to the others in your group.
12. As a group, the ten of you must now decide which of the proposals to accept. You may eliminate any of the land uses that you wish or you may keep all of them. Remember, however, the total land use area is limited to 1,280 acres. Of course, your evaluations of each of these uses should be the main factor in your decisions.
13. Again as a group, use the blank topographic map on Worksheet 17 and fill it in with the uses you have selected. You must keep these things in mind as you assign locations for the land uses:

    area required for each use (area given includes roads that must be built to it)
    location of each use in relation to the physical aspects of the land
    location of each use in relation to the other uses
14. Compare your completed map with those of the other teams in your class. How do they differ? Do you disagree with the placement of any of the uses on other maps? Which do you think is the best? Why?
15. What consequences were different? Did you overlook any consequences that others included? Did you include consequences the others did not think of?

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iii) Examples of Project and Test Questions

. Project. Environmental Disturbances

After a few years their numbers are as great as before, but to kill them, a stronger spray is needed. The spray often affects other animals which aren't doing any harm, or which may even be helping to control some other pests by eating them.

The result is two pests and not one, and one helpful animal dead.

The sprays soak into the soil and kill soil organisms, in particular the decomposers so that the nutrient cycles are interrupted.

As well, water runs off into rivers carrying the sprays and other chemicals used. Plants and water organisms may be killed by these chemicals or, as sometimes happens, the extra nutrients from fertilizers, causes water plants to grow very rapidly and choke the rivers, killing fish in the process.

In some Highland areas the change from subsistence to semi commercial agriculture, plus the rapidly growing population in an already densely populated area has increased the pressure on land use. These two factors have resulted in the clearing of a large percentage of the original forest, so that the habitats of animals such as the cassowary and the birds of paradise have been greatly reduced. Now free living cassowaries and birds of paradise have almost disappeared from the areas.

ACTIVITY 1. ENVIRONMENTAL DISTURBANCES

A brief survey of the causes of natural and man-made disturbances will serve as an introduction to this topic. To list them under these two headings would be sufficient e.g.

Natural	Man Made
Flooding	Mining
Tidal Waves	Forestry
Storms	Hydro Electric Power
Volcanoes	Pollution
Fires	etc.
etc.	

INTRODUCTION

Traditional agriculture required that the people live with nature, to work within Natures own capabilities.

When an area had been farmed over 2-3 years and fertility had dropped, producing poor crops, another area was cleared, the old area being left to recover over a period of 15-20 years, before being used again. The length depended on the area available, population pressure, and distance from the village.

Today, with a change from subsistence to a mixture of cash and subsistence and with increasing population pressure, the areas being cleared for agriculture are larger and the recovery period shorter in length. This means that the soil does not have time to recover properly, it is less fertile when it is cleared again for use, and when cropped becomes quickly exhausted. Recovery by regrowth is much slower and the soil is exposed to leaching and erosion, so that in some areas, recovery may be permanently reduced.

When areas are being used for commercial agriculture, such as sheep, beef or cropping, nutrients are not being recycled, because produce leaving the farm contains nutrients. Therefore to maintain production the application of fertilizers is necessary.

If your school has a garden then a brief study of methods used to maintain production could be useful.

Where large amounts of one crop are grown such as cocoa, coffee, or vegetables, especially those introduced from other countries, pests often increase in number, and spraying is required to reduce their numbers.

Sometimes the sprays don't kill all of the pests often because a few of the pests have a resistance to the spray. The ones that survived begin to reproduce and their offspring also are not affected by the spray.

ACTIVITY 2. COMMERCIAL AGRICULTURE

If a plantation is near the school, then an excursion could be made to do a brief study of the problems due to pests, methods of control and the degree of success of pest control. Students should prepare a set of questions before going, and the plantation manager given a set of questions before going so that he can gather necessary information.

Sample Questions:

1. How old is the plantation?
2. Has it always produced one crop? (some plantations may grow two).
3. Were there any pests, or were pests a problem when the plantation first began?
4. What pests are there now (one or several)?
5. Have they got worse in recent years?
6. What is being done to combat the problem? (Sprays etc).
7. How successful is spraying if it is used, and how often?
8. What other methods are used?
9. Do pests today cause much damage?
10. Have you found it necessary to increase the strength of the sprays over the years?
11. What would happen if spraying was to stop for a year or two?

If time permits, pupils could find out by asking villagers, or perhaps from their own knowledge, if these same pests do much damage in areas away from the plantation, or, if there has been an increase in damage since the establishment of plantations in the area.

In the discussion that follows point out to pupils that the environment has changed as a result of growing only one or two crops. Mention that natural predators of the pests may have been removed or forced to leave the area because of these changed conditions.

- Project. Ecology of local community near your school

> Because humans are consumers and depend on producers, we must manage our producers wisely. Land that we use for homes, highways, and shopping centers cannot be used for farmland. Perhaps just as important, this land is lost to the natural producers of the world. And the producers are lost to the herbivores and carnivores in the food webs that depend on them. These natural ecosystems are important to us for other than aesthetic reasons. We must conserve these resources for our future needs.

> Activity
>
> What are the biotic components—plants, animals, and microorganisms—of your community? How do they relate to each other? Can you describe any food webs or food chains that begin with the land in your community? After your class is divided into small groups, draw all of the biotic interrelationships you can think of on a large piece of paper. How are those relationships tied to the land?

Source: Biological Sciences Curriculum Study (BSCS) Investigating the Human Environment: Land Use. Colorado Springs: BSCS 1984 p 76.

- Project. Controversy in development. Suppose a local government proposes to build a very large dam in a wilderness area famous for the beauty of its landscape and for the variety of its animals and plants. The reason for the dam is to generate hydro-electric power for a local aluminium smelter needed for the industrial development of the country. The proposal is violently opposed by conservationists.

  (a) List some arguments which could be advanced by the conservation movement.

  (b) List some of the arguments which the government could put forward in favour of the dam.

  (c) Are there any circumstances under which you would agree that the dam could be built which could minimize its impact on the natural environment? Discuss your views.

  (d) What procedures should be followed by the government and the community to resolve these types of conflicting points of view?

  Source: Suggestion by author.

- Test Items

  (1) The following list represents the reactions of various individuals towards a Mangrove Swamp:

  Naturalist: A national treasure which we should preserve
  Detective: A menace

Real estate developer:	More land for me
Health inspector:	A hazard
Director of tourism:	A foreign exchange earner
Ship's captain:	A hazard
Charcoal burner:	My livelihood
Fisherman:	My livelihood
Citizen A:	A source of pleasure
Citizen B:	An economic resource
Citizen C:	A nuisance

In the statements above, there are two kinds of reaction to the mangrove swamp. Discuss the justification for the two types of reaction. In your answer consider

(i) the ways in which man uses the resources of the natural environment

(ii) examples of the ways in which an ecosystem such as a swamp provides niches for species harmful and useful to man.

(Knowledge 6 marks, Enquiry Skills 9 marks, Attitudes 0 marks)

Source: Caribbean Examination Council (CXC) Past Papers Integrated Science General Proficiency. Kingston Jamaica: CXC 1983 p 10.

(2) Choose any two of the following environmental controversies and write one page arguing for and against each side of the proposal.

(a) Building a freeway from the centre to the fringe of a major city
versus
Keeping a natural corridor of parkland which would be destroyed by the freeway.

(b) Keeping an area of rare mountain tundra vegetation as a wilderness area ie no access for people
versus
Opening the tundra area for recreation purposes.

(c) Culling grazing herds of native mammals (such as elephants in East Africa, antelopes in USA or kangaroos in Australia) where they encroach on farmlands and eat agricultural crops
versus
Allowing such animals to graze freely and compensate farmers for any losses.

Source: Suggestion by author

(3) Write one page on each of the following topics.

   (a) Getting rid of household rubbish
   (b) Reducing air pollution
   (c) Reducing the greenhouse effect
   (d) Preventing soil erosion

   Source: Suggestion by author)

(4) What do you understand by the term "sustainable development"?
   Write an essay about how your local area may develop economically over the next twenty years. In your essay include some suggestions about preserving the best features of your local environment so they can be enjoyed by the next generation. [Four pages]

   Source: Suggestion by author.

(5) In large cities city planners try to provide some areas of open space with grass, trees and other forms of vegetation.

   (a) List some of the reasons why city planners consider such areas to be necessary.

   (b) List some uses of these areas made by the city people.

   (c) Assume it is proposed to build a skyscraper on one of these areas in the middle of the city. The city authorities ask for comment. What arguments could you put forward for keeping the area?

   Source: Suggestion by author.

8.5 Resource Management

i) Rationale

The management of resources is an aspect of the broader issue of environmental management but because of its special significance in relation to development and the general quality of life it is treated separately in this section. In fact resource management issues are at the heart of many aspects of human welfare and biology educators have a special responsibility to highlight their importance. Inevitably, however, there must be some overlap between issues discussed in sections 8.4 and 8.5.

By resource management is meant the techniques and procedures used to develop and utilize resources such as food, natural resources such as water, forests and marine life, and energy resources. Courses in school biology can deal with the nature of resources and the different problems associated with managing renewable and non-renewable resources.

Areas of particular focus for school biology could be effective techniques in agriculture and other aspects of food production; problems of overfishing; exploitation of natural forests, especially rainforests; sources of energy and their effective management; the management of waste including recycling waste products the effective use of land resources and the management of wilderness and other natural areas for the purposes of conservation, scientific inquiry and recreation.

An especially important aspect of resource management is the search for alternatives. As non-renewable energy resources such as oil become depleted management policies need to be in place to search for alternatives such as wind power, solar energy and biological sources of energy. Alternative sources of food need to be explored and alternatives to scarce resources such as rainforest timbers carefully explored.

One of the most critical areas of resource management is the effective use of energy. For example a major issue in the rural areas of many underdeveloped countries is the use of local forest products for fuel. This had led to major degradation of the environment due to excessive tree felling leading to soil erosion and other environmental problems. Pollution aspects of energy resources are also important with carbon dioxide emissions from coal burning and the use of petroleum products threatening the planet with the greenhouse effect.

In both urban and rural areas the problem of waste disposal is now a major issue. In many large cities recycling of waste is only just beginning and the use of natural gullies as huge garbage tips has become an issue of considerable political sensitivity in many parts of the world.

A socially sensitive programme of school biology should not be satisfied simply to describe resources such as forests, marine communities, wilderness areas, animal resources and the like; nor to give academic accounts of energy processes such as photosynthesis or of energy cycles in natural communities of plants and animals. What is needed is a review of the applications of these ideas in resource management. A problem-solving approach is advocated mainly through case studies, to find effective ways to ensure that the resources of the planet will be used wisely so as to sustain them for future generations.

ii) Examples of Content

Example 8.19: Decisions about future use of land

School System: -

Approach: *A simulated planning exercise on use of land as a resource*

Source: *Stoltman, Joseph P. "Teaching Examples Land: Its Human Use" in Graves, Norman J. Land, Water and Mineral Resources in Science Education (Science and Technology Education and Future Human Needs Volume 4). Oxford: Pergamon Press for the ICSU Press 1987 pp 43-57.*

Land use decisions and the future

Key concepts

Land pollution, cropland reduction, desert-creep.

Lesson objectives

The student should be able to:

1. Describe the relationship between land use and population distribution;
2. Develop a cost benefit analysis of a major project affecting land use;
3. Use a time and space matrix to evaluate the types of local land use changes which have occurred and project them into the future.

Introducing the Activity

1. Begin the lesson by projecting Fig. 5.5 with an overhead projector, placing it on the board, or distributing a copy to each student in class. Ask the student to identify the main categories of elements shown in

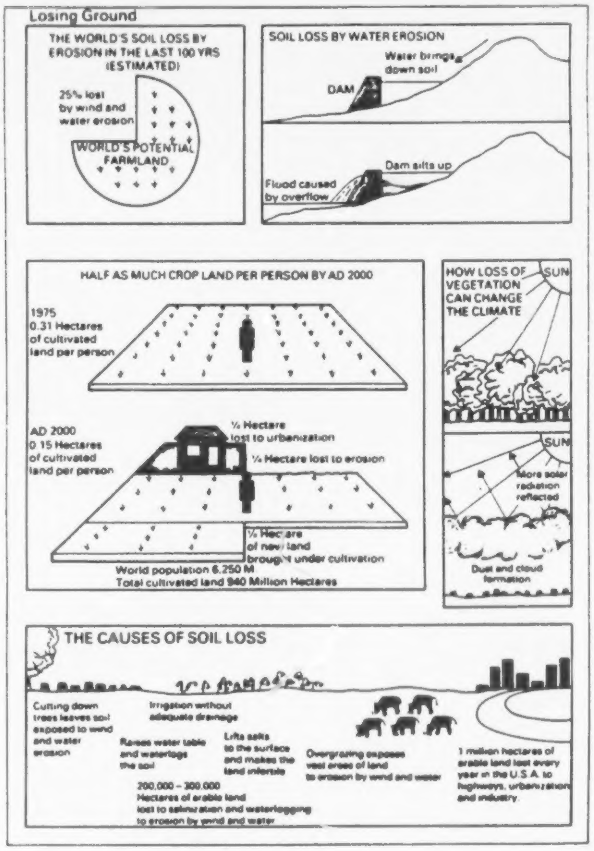
Losing Ground
THE WORLD'S SOIL LOSS BY EROSION IN THE LAST 100 YRS (ESTIMATED)
25% lost by wind and water erosion
WORLD'S POTENTIAL FARMLAND
SOIL LOSS BY WATER EROSION
Water brings down soil
DAM
Dam silts up
Flood caused by overflow
HALF AS MUCH CROP LAND PER PERSON BY AD 2000
1975 0.31 Hectares of cultivated land per person
AD 2000 0.15 Hectares of cultivated land per person
⅛ Hectare lost to urbanization
⅛ Hectare lost to erosion
⅛ Hectare of new land brought under cultivation
World population 6,250 M
Total cultivated land 940 Million Hectares
HOW LOSS OF VEGETATION CAN CHANGE THE CLIMATE
SUN
SUN
More solar radiation reflected
Dust and cloud formation
THE CAUSES OF SOIL LOSS
Cutting down trees leaves soil exposed to wind and water erosion
Irrigation without adequate drainage
Raises water table and waterlogs the soil
Lifts salts to the surface and makes the land infertile
200,000 – 300,000 Hectares of arable land lost to salinization and waterlogging to erosion by wind and water
Overgrazing exposes vast areas of land to erosion by wind and water
1 million hectares of arable land lost every year in the U.S.A. to highways, urbanization and industry.

Fig. 5.5

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Fig. 5.5. These are: erosion, urbanization, and land use change. Discuss ways in which those concepts have been developed in earlier lessons. Are there examples of additional land use issues which appear in Fig. 5.5? How does the example of the causes of soil loss in Fig. 5.5 demonstrate land use change?

2. Define each of the following items for the student. Land pollution – the process by which the land is rendered unsuitable for human activity. Pollution may result from over use of chemical fertilizers or herbicides, dumping of industrial refuse, and salt buildup from irrigation.
   Cropland reduction – the removal of land from active production of crops as a result of soil loss, salt buildup, urbanization, or chemical contamination.
   Desert-creep – the degree to which the vegetation of an area diminishes due to variations in weather patterns or from human use. Often referred to as desertification.

Developing the activity

Steps:

3. One of the important relationships to introduce is that of population distribution in relation to land use. Figure 5.5 projects those relationships to the year 2000. Get the students to evaluate the diagram as it might apply to the local area, the nation, and the world. How will the long term effects of urbanization and erosion bring about changes in the future? Notice in Fig. 5.5 that new land is being brought under cultivation. Will new land always be available in the future?
   Do not accept the information in Fig. 5.5 as absolutely true. It is a projection. How might such projections be inaccurate? What technical and social changes might alter the projection?

4. Read the article, "Consequences of the Aswan Dam, Egypt", Fig. 5.6, to your students or have them read the article as a homework assignment. Analyse the article for the benefits and costs of the project designed to increase the agricultural land of Egypt. Arrange the points from the article as in the Table 5.1.

TABLE 5.1

Benefits	Costs
1. Flood control	1. Salt buildup in soil
2.	2.
3.	3.

CONSEQUENCES OF THE ASWAN DAM, EGYPT

The annual Nile floods have now been controlled. These flood waters previously had three indispensable functions: (1) they flushed away salts from the soil that would otherwise choke plant life; (2) they swept away the snails carrying Bilharzia larvae, which causes a debilitating or fatal intestinal infection in humans; and (3) they left behind a new layer of fertile soil.

Built without sluices, the dam is trapping all the Nile's silt in its reservoir. The loss of this sediment load has led the clear river water to scour its bed, undermining numerous bridges and dams downstream. To prevent this, the Ministry of the High Dam proposed plans to build ten barrier dams between Aswan and the sea at a cost of $250 million – one-quarter of what the high dam cost.

Due to the decline in sediment discharge and, therefore, delta out-building, the Mediterranean Sea is eroding the delta and advancing inland, threatening many square kilometres of rich agricultural land. Approximately one-third of the delta front is actively eroding, some sections as rapidly as 2 metres per year.

Deprived of the Nile's rich sediment, much of the land already has depleted nutrient levels and needs artificial fertilizer. Two-thirds of the annual fertilizer usage is needed to make up for lost fertility and mineral content since Nile silt stopped coming. A number of minerals will also have to be added to the soil with time.

The marine food chain in the eastern Mediterranean has also been broken. The loss of nutrients formerly carried with Nile sediment has reduced plankton populations. As a result sardines, mackerel, and crustaceans have either died off or been driven away. Approximately 30,000 Egyptian fishermen have lost their livelihood.

The one undisputed benefit of the dam has been the conversion of 2,800 square kilometres from flood to canal irrigation, so that several crops can be produced on the land each year. The drawback has been that the canals are providing habitats for the snails that carry the Bilharzia larvae. A healthy human scarcely need set foot in the water to pick up the disease.

Adapted from: Griggs, G. and Gilchrist, J. *The Earth and Land Use Planning*. Massachusetts: Duxburg, 1977, pp. 290–292.

Fig. 5.6

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5. Evaluate each of the items in the cost–benefit analysis and identify which of them relate directly to land use. What other land use activity may be evaluated using a cost–benefit analysis? List the consideration which might be made when deciding the future of a land use decision. How might land use decision affect people in 20 or 30 years?

Concluding the activity

6. The values of the past are important when considering land use decisions presently and for the future. Table 5.2 presents a matrix for classifying information and placing it in both a time and space framework. Direct the students to work in groups of two or three individuals and complete as much of the matrix as possible. Encourage the students to speculate regarding future land uses and how they will affect people. Table 5.2 has been partially completed in order to provide ideas for the teacher.

TABLE 5.2. *Land Use Over Time: The Case of Bangalore, India*

Aspects of Land	Earliest Residents	Scientific and Technological Events	Grandparents Time	Scientific and Technological Events	You (Now)	Scientific and Technological Events	Future (your predictions for the year 2050)
Feelings about the land	Spiritual Affinity	Water storage Food storage	Land as a resource Land as a source of wealth	Better transport	Conservation of land Planning for the future use of land	Chemicals for plants and pests Machines of various kinds	Environmental Ethic Value of land increases Holistic views
Direct activities with land							
Use of land resources	Forests Farming Grazing Village sites	Use of draft animals Irrigation systems	Urban areas Manufacturing Construction materials	Specialized machines for agriculture and mining, Green Revolution	Urban sprawl Suburban sprawl Transportation uses increase	Computer Nuclear Power Regional water supplies	Renewable energy from land Recreational uses High rise buildings
Type of Man-Made Structures on Land							
Owners of the land	Maharaja Tribal	Irrigation tanks, Pottery and brick making	Corporations Government Banks Individuals	Tractors Harvesters Deep wells	Small farmers Government Corporations Development agencies	Grain storage for long term Biogas, market data	

Adapted from: *People and Environmental Change*

Local examples

7. Use the idea of a matrix as demonstrated in Table 5.2 and develop a similar matrix for the local community. The entire community might be the subject of the investigation, or several parcels of land within the community may be selected for analysis. Students should rely upon family and community members as sources of information.
8. Complete a local study to determine the number of people who are employed on units of land where the use is quite different. For example, a farm might be compared with a local market, or business centre. A local manufacturing or processing plant may be available and the number of employed persons obtained. In some instances, data on a land use which is not in the community may be obtained and compared with the local land uses.

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Example 8.20: Crop productivity - a community study

School System: Philippines secondary school biology
Approach: Class project on management of agricultural crops in the local district
Source: Institute for Science and Mathematics Education Development (ISMED) "Activity No. 5 Crop Productivity: A Community Study" in Teacher Resource Material on Plant Diseases. Manila: University of the Philippines ISMED Unpublished mimeographed material 1980.

Crop Productivity: A Community Study

This activity intends to expose teachers and students alike, to actual conditions in the community particularly with regard to crop productivity and then arrive at qualitative assessments accordingly.

The class could be divided into different groups, each group focusing on any of the following areas:

1. Major crops grown in the community.
2. Major types of diseases that affect the crops, whether pathogenic or due to adverse environmental conditions.
3. Presence of large-scale industries or other human activities that disrupt the ecological balance of the community.
4. Presence of cooperating agencies that help the community promote its crop production.
5. Measures to recommend based on findings of the study.

The findings of each group may be presented to the class in the form of a group report. Discussions that would ensue after the report would ensure a holistic approach to the topic, thus making this activity appropriate for what it is really intended for a culminating activity, perhaps, not only for the topic on plant diseases but for the entire course in biology as well.

Data gathering may be in the form of any of the following:

1. Field visits to gather samples of crops afflicted with disease. It is understood that these specimens will be examined in school.
2. Interviews of farmers, farm operators and personnel of agencies involved in crop productivity and community residents.
3. Mapping of the entire community.

Example 8.21: Efficiency of domestic cooking appliances

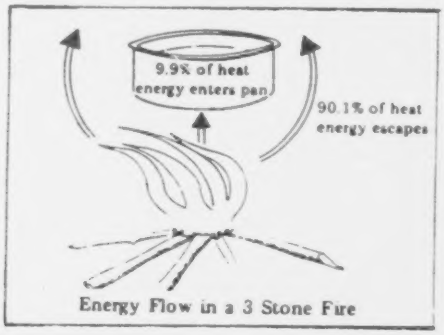
School System: Kenya secondary school science
Approach: Project to determine efficiency of traditional cooking appliances
Source: Rugumayo, Edward B. Energy as a Unifying Concept in Ecology Teaching in Secondary School. A paper presented to the annual meeting of the International Union of Biological Sciences Commission on Biological Education, Moscow 3-10 September 1989 pp 6-7.

Efficiency of domestic cooking appliances

This the time to introduce the concept of efficiency of domestic cooking appliances, which over 85% of the population use, and how improving their efficiency would reduce energy consumption, which in turn would contribute towards sustainability of the forest resources and improved state of the resouce base.

In rural areas of Africa, the three-stone open-fire cooking arrangement (Figure 5) is the most popular. Students should be made to conduct simple experiments to determine the efficiency of this arrangement, which is about 9.9% and consider how to improve its efficiency.

The next stage to consider is the jiko and its various designs and efficiencies. These should be compared with gas and electric cookers. The traditional jiko is 20% efficient. The Kenya ceramic jiko (an invention of local craftsman) is 30% efficient. (Figures 5,6,7). It uses 30-50% less fuel than the traditional jiko, and produces 20% less poisonous carbon monoxide than the traditional metal jiko.



Energy Flow in a 3 Stone Fire

Figure 5: A Three Stone Fire : 9.9% Efficiency

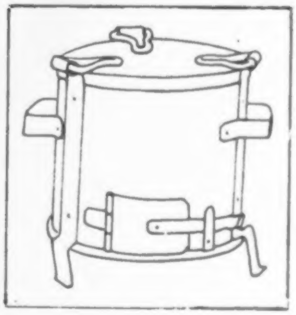


Figure 6: Traditional Metal Jiko : 20% Efficiency

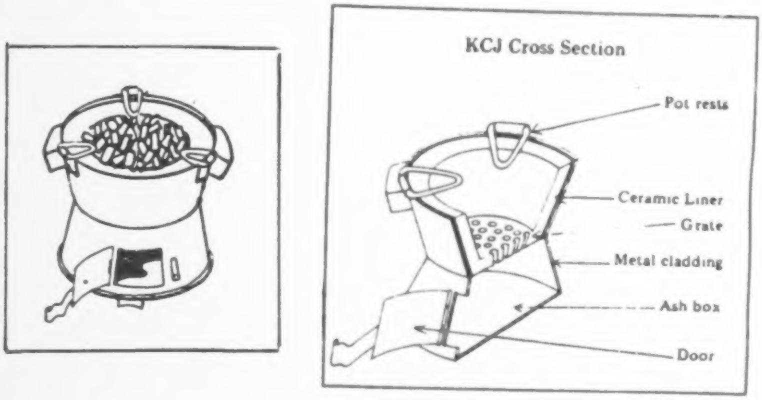

KCJ Cross Section
Pot rests
Ceramic Liner
Grate
Metal cladding
Ash box
Door

Figure 7 : Kenya Ceramic Jiko (KCJ) : 30% Efficiency

Example 8.22: A national energy diagram

School System: *Kenya secondary school science*
Approach: *Description of project for drawing a diagram to show sources and uses of energy in a particular country*
Source: *Rugumayo, Edward B. Energy as a Unifying Concept in Ecology Teaching in Secondary School. A paper presented to the annual meeting of the International Union of Biological Sciences Commission on Biological Education, Moscow 3-10 September 1989 pp 8-10.*

A National Energy Diagram - Kenya

Seventy-five percent of Kenya's energy requirements are obtained from biomass - fuelwood, charcoal and agricultural residue. The rest of the energy is obtained from imported fossil fuels and hydropower, locally produced hydropower and geothermal power. A small percentage is derived from renewable solar and wind energy sources. Since biomass is the principal energy source for Kenya, the teaching of ecological energetics becomes even more urgent and relevant.

Students should be supplied with up-to-date data of energy survey of their country. This would include energy demands (surplus/deficit), sources of energy and future projections. In this way, students are enabled to conceptualize energy issues at a national/global level. If energy demand for fuelwood is greater than the supply, then there is a deficit, and this means that wood cannot be harvested on a sustainable basis. Some important decisions have to be made and steps taken to meet the shortfall - by planting more trees, importing woodfuel, reducing wood consumption by substituting other energy sources, e.g. imported fossil fuels (kerosene) for household cooking, etc. But the steps taken must ensure that the rate of tree planting is in excess of tree felling.

Finally, an attempt should be made to draw a national energy diagram for Kenya (Figure 8). Unfortunately, it has not been possible to obtain latest data concerning energy consumption and needs, as some of these have not been computed at national level.

Conclusion

Energy as a unifying concept in biology can be introduced to simplify the teaching of ecology, especially the ecosystems and the man-ecosystem interface. The concept has the added advantage of involving students in their own small projects at the local level. It is also a concept that cuts across all the sciences, and has a daily application. It encourages both the teacher and student to obtain data, however approximate these might be, to make their systems diagrams more complete. This approach also encourages students to think in terms of the impact on the environment of the various economic and industrial activities, and how they can endeavour to live in a sustainable way.

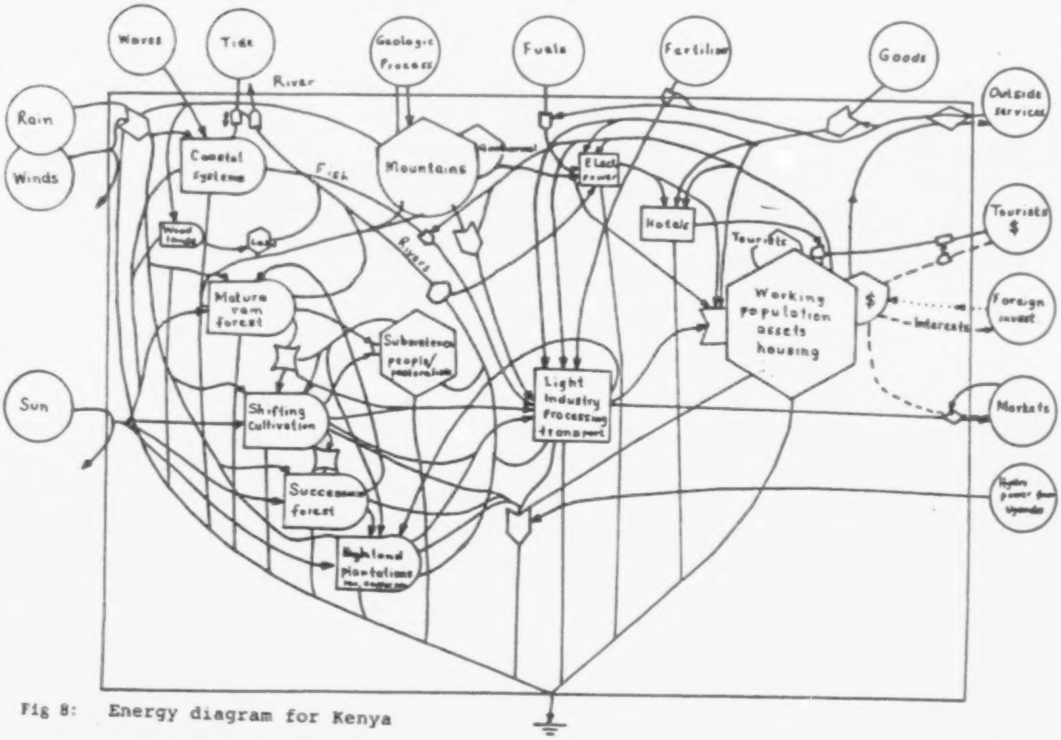

Waves
Tide
Geologic Process
Fuels
Fertilizer
Goods
Rain
Winds
River
Outside services
Coastal Systems
Fish
Mountains
Geothermal
Elect. power
Hotels
Tourists $
Tourists
Wood
Rivers
Mature rain forest
Subsistence people/ pastoralists
Working population assets housing
$
Foreign invest
Interests
Sun
Shifting Cultivation
Light Industry Processing transport
Markets
Successional forest
Hydro power from Uganda
Highland Plantations

Fig 8: Energy diagram for Kenya

Example 8.23: Biological systems as energy sources

School System: -
Approach: *Suggestions for practical activities on biological systems as energy sources. Management implications would need to be stressed*
Source: *Tribe, Michael and Pritchard, Alan J. Biological Systems, General Sources and Biology Teaching (Science and Technology Education Document Series No. 9). Paris: Unesco 1984 pp 48-49.*

1. Make a model biogas generator

Biogas technology used on a small scale to provide lighting and heat for individual families can be explored by (a) visiting community-size gas plants, if they occur locally, and (b) by inviting pupils to design and build a biogas generator, based on their studies in biology. Fig. 20 illustrates a model generator which can be made out of simple materials. Samples of the gas can be collected by pressing down on the inner bottle, and then tested, using a burning taper.

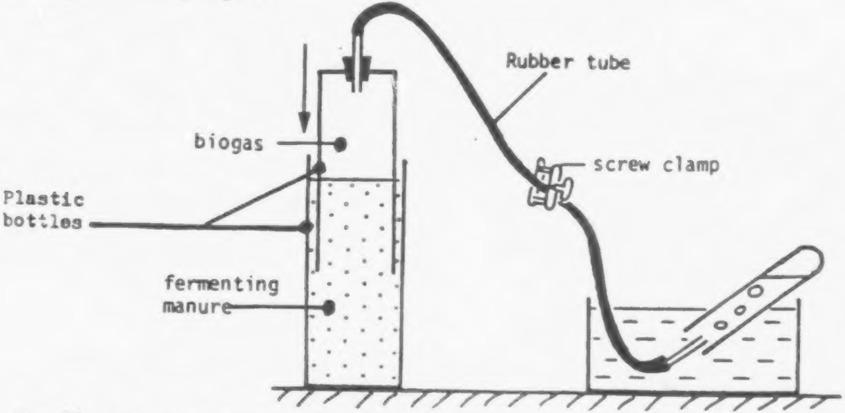


Fig.20 A simple biogas generator.

2. Economics of Fuel Usage

Associated with work on making a biogas generator, pupils can be given exercises, using data, to compare efficiency of fuel use in a simulated situation. A farm with waste organic matter (e.g. a coffee farm with waste husks) may need to consider whether to install a biogas plant or to sell the waste for some other use (e.g. a local clay works may purchase the husks). A biogas plant would enable the farm to replace petrol as the electricity supply for the farm and would provide fertiliser. Installation of the biogas plant would involve borrowing money and paying it back with interest. Such a situation can be used to develop role-playing, quantitative worksheet exercises and simulation exercises. The energy potential of cellulose can be calculated by the pupils, the efficiency of the energy transfer to electricity can also be calculated, and the whole exercise can be related to economic issues, i.e. the capital cost of installation (including interest charges), together with the potential benefit from no longer depending on petrol, versus potential profit from sale of the waste for other purposes.

3. Laboratory Work and Project Work

Investigate the most energy-efficient way of using school land (e.g. cattle, forest, agroforestry = crops and trees).

This may be an overall project which covers laboratory and field investigations into the nitrogen cycle (including looking at leguminous roots); photosynthesis and respiration (including practical work on Crassulacean Acid Metabolism and C4 Photosynthesis to illustrate the efficiency relative to the topic in question) and the use of products. Such a project would cover a variety of teaching strategies and be concerned to deal with ecological efficiency, consumers and food chains, decomposers, biomass and pyramids, as the biological principles used eventually in contributing to making judgements on the best use of the land.

Example 8.24: Management of programme of control of an agricultural pest

School System: United Kingdom secondary school biology
Approach: Problem solving based on genuine case study of apple production. Scientific basis of a past management programme reviewed and analysed
Source: Spellerberg, Ian F. and Pritchard, Alan J. Ecology, Ecosystem Management and Biology Teaching (Science and Technology Education Document Series No. 10). Paris: Unesco 1984 pp 50-55.

Problem

It is possible to use a problem situation to create a series of activities for pupils which aim to introduce them to qualitative and quantitative methods of study, simple models, such as a pyramid of numbers and theories such as those concerning interactions based on producers and consumers in ecosystems (see p.46). Dr. Spellerberg, in the third chapter (p.30), gives an example of the emergence of the small red mite (*Panonychus ulmi*) as a pest in apple orchards in Britain and refers to the importance which this illustrates of integrated pest management programmes as part of orchard management. The context here is Britain, but the approach suggested as follows could be used with other more appropriate examples elsewhere in the world. Apple farming is an important economic activity in parts of Britain and the economic welfare of many families in such areas is dependent upon successful apple crops. Other families are dependent also upon effective apple farming to provide them with an important item of their diet at prices which they can accord. The economics of fruit farming is clearly of importance to a community, both for producers and consumers. This might be an interesting starting point for some groups of pupils, particularly in areas where fruit farming is a significant economic activity. A programme of work centred on the problems of pest control, aiming to teach some ecology within an issues study framework, may be developed as a short project.

Stage 1. The pupils explore the elements that contribute to the cost of apples, up to the point when the crop is ready to leave the farm for distribution to the shops. This could be guided class discussion, together with small group work, to establish ideas about possible component costs (e.g. various forms of labour, petrol for machinery, packaging materials, storage, fertilisers, pesticides, etc.). Those pupils from families engaged in fruit farming may be able to make special contributions from their family experience.

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Stage 2. The work is developed into a planned farm visit, during which small groups of pupils take on different tasks (e.g. interviewing, collecting data on costing) leading to the presentation, in appropriate forms, of their findings (e.g. edited tape-recording, bar charts on overhead projector transparency, photographs, etc.) and identification of the relative costs of chemical pesticides in apple production.

Stage 3. At this stage, a more formal presentation, possibly including a film, by the teacher of the problem of pests in general in agriculture, with some examples of changes in pests associated with particular changes in agricultural practice (see Chapter 1 of the book for the examples). This could be developed into a short study by the pupils of changes in recent years in pests and pest control, in this case in apple farming. Reference back to the information gathered from the farm visit, together with looking at, for instance, the farming notes in back copies of the local newspaper, would reveal that the red spider mite (*Panonychus ulmi*) is a relatively recent pest and a costly one. Thus, a problem is identified - why should this mite be a pest now, when it was not formerly a pest?

Stage 4. A second farm visit : (a) to collect samples of the fauna of the apple trees. The pupils working in small groups collect fauna by picking leaves from selected trees and tapping whole branches of the same trees over a tray. (The collecting techniques need not be treated fully as sampling techniques.) (b) to look at the effects which red spider mites have on the trees and discuss with the farmer how this affects his crop.

Stage 5. Laboratory observation of the field samples involving :

(a) a study, with the aid of notes, film-strips and photographs of the life cycle and feeding behaviour of red spider mites;

(b) separation into groups of the fauna collected, using a simple key written for this exercise;

(c) estimate of numbers of each group and construction of a simple pyramid of numbers;

(d) a study (from information provided) of the feeding relationships of red spider mites; the identification of simple predator/prey relationships.

Stage 6. An exploration of the problem - why have red spider mites fairly recently become pests of economic importance in apple farming? This could be through a study using available data in the form of problem solving exercises. This approach lends itself to individual, small group and whole class activities. The pupils are provided with a short introduction, describing the experiments carried out and data presented in a suitable form, together with questions which involve a careful consideration of the data. The form of presentation of the data, other forms of evidence and the structuring of the questions need to be related to the age and ability of the pupils.

Fig. 22 shows the results, as presented in a research paper, of a study of the effect of DDT sprays on the fauna of apple trees (Muir, 1966). Data such as this can be presented in simpler form for use by pupils; for instance, this data could be presented on three overlapping pages, with interleaved transparent sheets, for easy comparison of population changes (Fig. 23). Such a format allows for use both by individual pupils as well as on an overhead projector with the whole class. The questions would need to guide the pupils through the data, involving a consideration of the comparative changes in population of the red spider mite and its main predator (the mirid, *Blepharidopterus angulatus*), and getting the pupils to draw upon their earlier work on the life cycle, breeding habits and feeding relationships of the red spider mite - seeking explanation of the data given.

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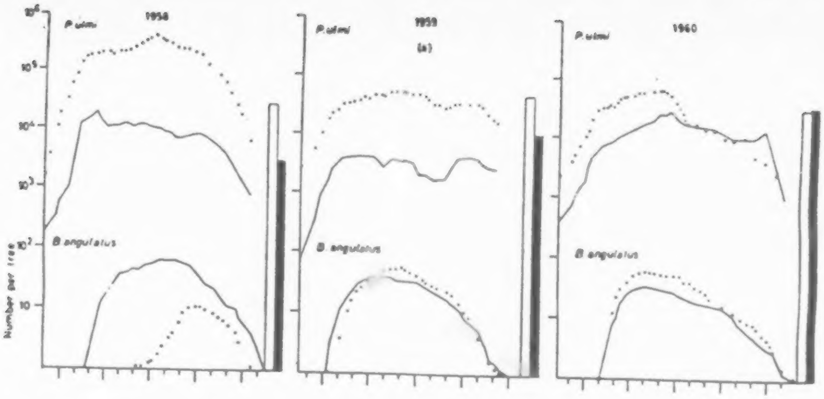
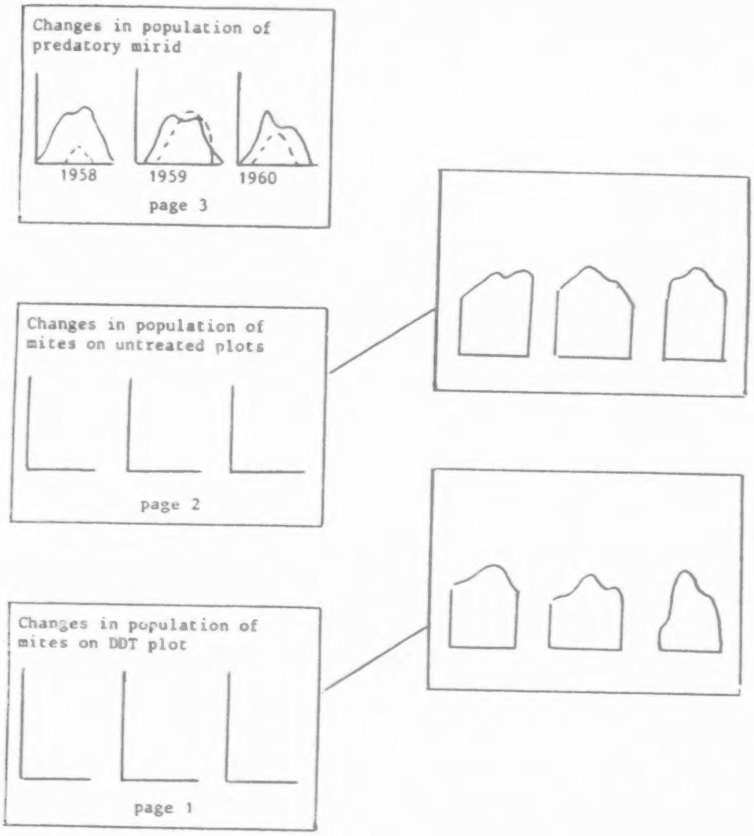


Fig. 22. Changes in populations of predatory mirids (*Blepharidopterus angulatus*) and red spider mites (*Panonychus ulmi*). The total number of winter eggs of red spider mite are represented as histograms, white for 'DDT' plots and black for untreated plots.


Changes in population of predatory mirid
1958
1959
1960
page 3
Changes in population of mites on untreated plots
page 2
Changes in population of mites on DDT plot
page 1

Plain sheets

Transparent sheets with population data coloured in.

Fig. 23.

Stage 7. A general consideration of integrated pest management programmes as part of orchard management - with some examples of practices in orchards other than apple orchards - perhaps in other parts of the world which produce crops sold also in the school's locality.

In the planning of this type of work, it is possible to use simple charts to give (a) an overview of the sequencing and length of time of activities in which the pupils will be engaged, and so help in the planning to sustain the pupils' interest and enthusiasm, e.g.

Stage	Whole class work	Small group work	Individual work	Lab. work	Field work		Film	Lecture	Role play	Discussion	Use of reference material
					Type (a)	Type (b)					
1											
2											
3											
4											

Fig. 24.

and (b) using a chart, one can map at what stages in the project the pupils will come across new ideas and skills and then be expected to put them into practice, e.g.

Stages :	1	2	3	4	5	6	7
Food web							
Pyramid							
Food niche							
Breeding population							
Community							
Analysis							
Hypothesis formation							
Experimental design							
Drawing conclusions							

✓ introduction to idea/skill * use of idea/skill

Fig. 25.

Example 8.25: Poverty game. Management of subsistence agriculture

School System: -

Approach: Description of simulation game to illustrate the need for careful planning in the production of subsistence crops

Source: Lehman, Jürgen and Schilke, Karl "Games and Simulations in Biology Teaching" in Unesco: New Trends in Biology Teaching Volume V. Paris: Unesco 1987 pp 75-101.

Note: Game originally devised by T. Dunlop (n.d.) Poverty Game. Oxford: Oxfam Youth Department.

The next example is the 'Poverty Game', devised at Glasgow by T. Dunlop (n.d.). The instructions for play cite three objectives: 'the vulnerability of the subsistence farmer to chance; the difficulty of taking decisions in this precarious situation; the vicious spiral of misfortune, poverty, malnutrition and disease.'

In a fictitious district of West Africa there are a number of neighbouring villages, each of which starts out with ten identical fields. Every year the inhabitants decide which of six various crops they want to cultivate. They must take care to grow at least three different types, and at least two fields must have protein crops. The farmers must gather at least 450 points in order to feed themselves and their families. If they reach or surpass this figure the village inhabitants are in good health. However if the harvest does not produce this minimum amount, the farmers suffer from malnutrition and easily succumb to illness. If this is the case, they cannot work the land adequately. Should a village team slip considerably below the minimum requirement it can ask for help. The villages can also take measures against hunger by building a first-aid station or irrigating their fields (Fig. 4).

Each simulated production year begins with the cultivation of the fields, and the appropriate data are then recorded on the work sheets. The dice are thrown and the result determines whether the year is dry or wet. This information helps in calculating the yield of the harvest.

Now a card is drawn from a pack describing various disasters, e.g. destruction of crops by pests. The effect of this event on the harvest is calculated. Then the villages check whether they are above or below the minimum amount and either credit themselves with a certain amount or use a table to calculate the extent of their malnutrition. They enter these losses on the work sheets and thus begin the new year at a disadvantage. This means that they must now try to increase their harvest by careful crop planning. In order to survive they must take a calculated risk. A compromise must be found between too great and too small a risk. The villages' decisions are recorded on the work sheets, which means that their tactics are open.

In the instructions accompanying the game the user will find a selection of questions which can be used to structure the subsequent evaluation discussion.

CROP CARD

	crop	wet	dry
root	**yams**	70	20
	cassava	40	60
cereal	**maize**	60	30
	millet	30	50
protein	**groundnuts**	50	30
	peas	40	40

Your village has 10 small fields. In these you must grow at least 3 different crops for variety in diet. You must grow at least 2 fields of protein crops.

If your agricultural produce falls below 450, your village will suffer malnutrition and possibly outbreaks of illness. This will mean you cannot work well in the fields and therefore your crops the next year will not be so good.

If you produce more than 500 units, you may store up to 50 units for the next year.

If the food supply falls below 200 for two years, people starve to death.

Fig. 4. A crop card from the 'Poverty Game' (T. Dunlop).

iii) Examples of Project and Test Questions

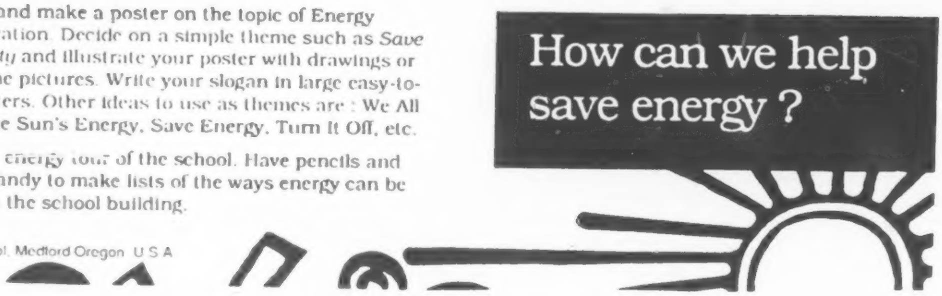
. Project. Conserving energy

ENERGY CONSERVATION

Design and make a poster on the topic of Energy Conservation. Decide on a simple theme such as *Save Electricity* and illustrate your poster with drawings or magazine pictures. Write your slogan in large easy-to-read letters. Other ideas to use as themes are : We All Need The Sun's Energy, Save Energy, Turn It Off, etc.

Take an energy tour of the school. Have pencils and paper handy to make lists of the ways energy can be saved in the school building.

Gracia Brown
Lone Pine School, Medford Oregon U S A


How can we help save energy ?

Source: Gujarat India. Anon. "Energy Unit for Primary Grades" Energy Education Vol 2 Nos 1 and 2 March/June 1989 (Gujarat Energy Development Agency) pp 33-35.

. Project. Effective disposal of household wastes

Test Yourself

Part A

Questions 1 to 5 are about the situation below.
Suppose you collected the following wastes in your home.

a. grass cuttings
b. rusted can
c. bottles
d. wilted kangkong leaves
e. fallen leaves in the yard
f. rotten papaya fruit
g. old newspaper
h. plastic bag
i. animal manure
j. intestines and internal organs of fish and chicken
k. grated coconut meat after getting the milk
l. branch of guava tree
m. heads of fried fish
n. heads and feet of boiled chicken

1. Separate the waste into dry waste and wet waste. Use letters only.
2. Wet waste comes from ______.
   a. plants only
   b. animals only
   c. plants and animals
   d. plants, animals, and bodies of water
3. Classify the dry waste and wet waste into the 5 F's. Use letters only.

Dry waste

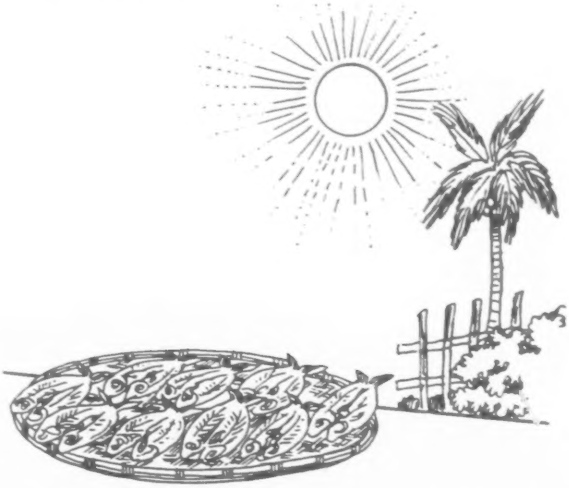
Factory Materials	Future Use	Fuel

Wet waste

Fuel	Feeds	Fertilizer

4. Fatima's family has a dog and a few chickens. The family uses the following wastes as feeds.
   grated coconut meat after getting the milk
   heads of fried fish
   heads and feet of chicken
   Will you also use these wastes as feeds? If yes, why?
   If no, why not? How will you use the wastes?
5. In the list of waste materials a to n, which will you bury in the ground or give to the garbage collector? Why?

Questions 6 and 7 are about the situation below. Aling Carmen prepared dried fish.



6. Before drying, the fish weighed 1,000 grams (1 kilogram). After drying, the fish weighed 400 grams. This shows that ______.
   a. fresh fish has a large amount of water.
   b. fresh fish has a small amount of water.
   c. fresh fish has more protein than dried fish.
   d. fresh fish has more calcium and vitamin D than dried fish.

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7. Fresh fish decays after a day. Aling Carmen's dried fish did not decay for two weeks. This is because bacteria and fungi that cause decay need
   a. air.
   b. water.
   c. soil.
   d. sunlight.

Questions 8, 9, and 10 are about the fertilizer basket in Totoy's yard.

8. Totoy has to take care of the fertilizer basket. Which of the following should Totoy do?
   a. Water the waste on dry days.
   b. Step on the waste to pack it tightly.
   c. Dry the waste by putting it in sunlight.
   d. Cover the waste during a heavy rain.
   e. Remove decaying animal parts.
   f. Loosen the waste gently with a stick.
9. Explain why Totoy should do each activity you chose in 8.
10. Which of the following things will happen in the fertilizer basket within four months?
   a. The temperature will go up.
   b. Bacteria and fungi will feed on the waste.
   c. The waste will become finer.
   d. The waste will become fertilizer.
   e. Small animals like insects and worms will feed on the waste.
   f. The waste will give off a bad smell.

Part B

1. Do you separate wet waste from dry waste in your home?
   ☐ Yes, sometimes
   ☐ Yes, always
   ☐ No
2. Do you separate wet waste from dry waste in school?
   ☐ Yes, sometimes
   ☐ Yes, always
   ☐ No
3. Do you reuse wet waste and dry waste?
   ☐ Yes, sometimes
   ☐ Yes, always
   ☐ No

4. Did you make a fertilizer basket at home?
   ☐ Yes
   ☐ No
5. Do you put wet waste into your fertilizer basket at home?
   ☐ Yes, sometimes
   ☐ Yes, always
   ☐ No
6. Do you put wet waste into your fertilizer basket in school?
   ☐ Yes, sometimes
   ☐ Yes, always
   ☐ No
7. Do you take care of your fertilizer basket?
   ☐ Yes
   ☐ No
8. Have you told your family and friends about the benefits of reusing waste?
   ☐ Yes
   ☐ No

Source: University of the Philippines Science Education Center (UPSEC) Goodbye, Waste! Manila: UPSEC 1988 pp 22-25.

- Project. Overfishing. In a particular tropical island country coral lagoons were once rich in marine animals such as shellfish, octopus, crayfish and various lagoon fish. They were a main source of food in the local markets. Use of damaging fishing methods such as dynamiting and fine-mesh netting depleted the stocks to a level where it was not economic to exploit the lagoon stocks for sale in the local markets. A whole industry was destroyed by overfishing. Consider this story and answer the following questions.

  (a) What caused the stocks of living things in the lagoons to decline? Give details.

  (b) List some regulations which you think the government should enforce to stop overfishing and restore the lagoon industry.

(c) What do you think the effect of the loss of the lagoon fishing industry had on (i) the way of life of the local people and (ii) the economy of the country?

Source: Suggestion by author.

- Test Questions

(1) What is meant by the statement that the Earth is a finite system?

- (a) It has a limited supply of natural resources.
- (b) It has an unlimited supply of natural resources.
- (c) It has a plentiful supply of natural resources?
- (d) It has a few natural resources.

(2) It is often said that the Earth is facing a 'population crisis'.
This means

- (a) an increasing population and decreasing use of natural resources.
- (b) an increasing population and increasing use of natural resources.
- (c) a decreasing population and increasing use of natural resources.
- (d) a decreasing population and decreasing use of natural resources.

(3) Which one of the groups below contain only renewable resources?

- (a) copper, gold, petroleum, coal
- (b) water, pigs, air, breadfruit
- (c) bananas, yams, bread, plastic
- (d) flies, ants, stones, metal

(4) Raising the living standard of a population means

- (a) not using natural resources
- (b) using less natural resources
- (c) using more natural resources
- (d) careless use of natural resources.

Source of items 1-4: Ministry of Education Papua New Guinea *Science Ecology Item Bank Grade 9 Unit 5*. Boroko: Department of Education 1984 pp 5-6.

(5) The following comparative figures show the average catch of halibut fish in the Pacific Ocean fisheries from 1918 to 1942 -

Year	Average Catch
1918	132
1920	148
1922	135
1924	105
1926	90
1928	72
1930	65
1932	82
1934	85
1936	100
1938	114
1940	120
1942	132

Answer (a) and (b).

(a) It is reasonable to conclude that some conservation regulations were introduced in the year -
A. 1928 .. ..
B. 1930 .. ..
C. 1932 .. ..
D. 1942 .. ..

(b) If the intensity of fishing continued after 1942 at the same average rate operating between 1934 and 1942, it would be reasonable to expect the catch to begin to decline again about the year -
A. 1940 .. ..
B. 1946 .. ..
C. 1952 .. ..
D. 1956 .. ..

(6) The most satisfactory way of ensuring that kangaroos survive and are available in their natural habitat for future generations of scientists to study is to -
A. set aside national parks for tourists and visitors to see kangaroos in nature .. ..
B. breed kangaroos in zoos .. ..
C. stop farmers shooting kangaroos .. ..
D. set aside 'wilderness areas' for kangaroos from which visitors are banned .. ..

Source of items 5-6: Cull, R.G., McDonnell, K.S. and Meyer, G. Rex Objective Tests in Science for Third Level NSW Higher School Certificate. Brisbane: The Jacaranda Press 1967 pp 204-205.

(7) The inhabitants of many of the Caribbean countries are cutting down their forests to use as fuel in an attempt to help solve their energy problems. Experts from major international institutes recently predicted that unless effective measures are taken to manage forests, Haiti for example, will almost be completely deforested and will lose most of its top-soil by 1990. By the end of the century most of Haiti could become a dry, barren wilderness.

(a) Outline how the existence of forests is important in maintaining soil and water resources, plant and animal life in mountainous countries like Haiti.

(b) In view of the crisis mentioned in the first paragraph, what effective measures for managing forests would you recommend
   (i) on a short-term basis?
   (ii) on a long-term basis?

(Knowledge 3 marks, Enquiry Skills 10 marks, Attitudes 2 marks)

(8) The Caribbean sea is used regularly for transporting oil from one territory to another. It is claimed that a major oil spill or continuous oil spills have serious effects on the economic development of the region.

(a) State what effects you think oil spills may have on the life processes of

   (i) plankton (microscopic plants and animals),
   (ii) fish, and
   (iii) seabirds.

(b) Chemical substances known as dispersants, which break up large oil globules into small droplets, have been used successfully to clean up oil spills.

   (i) Bearing in mind that oil can also be broken down by microscopic organisms into simpler substances and can evaporate, explain how the action of dispersants could reduce the harmful effects of oil spills on the ecosystem of the sea.

   (ii) Comment on the statement:
   It is the responsibility of the larger countries trading in oil to keep the oceans clean. The technology available for dealing with oil spills demands more money than small territories can afford.

(Knowledge 6 marks, Enquiry Skills 7 marks, Social Awareness 2 marks)

(9) Suppose a Forestry Department investigated the use of quick-growing forests as energy farms to produce fuel in order to reduce oil imports and a preliminary investigation revealed the following facts:

(i) There is only a limited area available for energy farms and this is on hillsides.

(ii) To produce an adequate supply of fuel on the available land, an energy farm would have to yield at least 30 tonnes dry-weight of wood per hectare per year.

(iii) The average yield of existing wild hill-side forests is 4 tonnes dry weight per hectare per year.

After gathering this information, the Department still wishes to have energy farms which will meet the target yield.

(a) What further investigations would you suggest to the Forestry Department? Briefly outline how ONE of your suggested investigations could be carried out.

(b) Suppose the target can be met, do you see any disadvantages in developing energy farms? You should support your answer fully.

(Knowledge 4 marks, Enquiry Skills 11 marks, Social Awareness 0 mark)

Source of items 7-9: Caribbean Examinations Council (CXC) Past Papers Integrated Science General Proficiency. Kingston Jamaica: CXC 1983.

8.6 Understanding and Influencing Change

i) Rationale

In other sections of this book emphasis has been placed on the idea that a socially oriented programme of school biology should also be future oriented. This implies that it should help students understand and be involved in societal change in a rational and effective way.

Changes occur continuously in our individual lives, in the life of a family, in institutions, in the local community and in the wider framework of society as a whole. Changes are of two types. They are either purely reflexive responses to some unexpected or unplanned event or they are based on rational problem solving and planning. The characteristics and elements of these two types of change have been described and discussed by the American sociologist Ronald G. Havelock (14). He proposes two types of models of change, Model A and Model B.

Under Model A change in any system is seen to be ad hoc and spontaneous and not following any overall plan. It is almost like a reflex action in nervous physiology. Some event occurs which disturbs an otherwise stable situation - a stimulus is applied. This may be something as simple as a parent visiting a school to protest at how grades are awarded to a son or daughter. It may be a situation where one class gets low grades in quantitative aspects of biology. Some follow-up activity then occurs to deal with the incident. A teacher/parent meeting may be called or a computer purchased for the biology laboratory. The disturbance is seen as a "one-off" and the solution is also a "one off". The activity has some effect on the situation and the disturbance is either rectified or remains as a problem. If it remains as a problem, further cycles of change are likely to occur, but if they follow this pattern the changes will lack any overall direction or plan.

Under Model B change occurs as a result of more rational decision-making and a problem solving approach is adopted. As in Model A, a disturbance occurs but instead of an immediate superficial response being initiated there is recognition of a basic need and an attempt to analyze the need and express it as a problem to be solved. This in turn leads to a search for solutions to the problem and a try-out of alternative solutions. If an appropriate solution is found and applied then the initial disturbance is remedied. If the solution and its application are not satisfactory the cycle will be repeated.

Students should appreciate that reflexive change (Model A) cannot lead to effective sustained growth. Change based on a rational problem solving approach (Model B) will ensure that growth is purposive, sustained and carefully controlled.

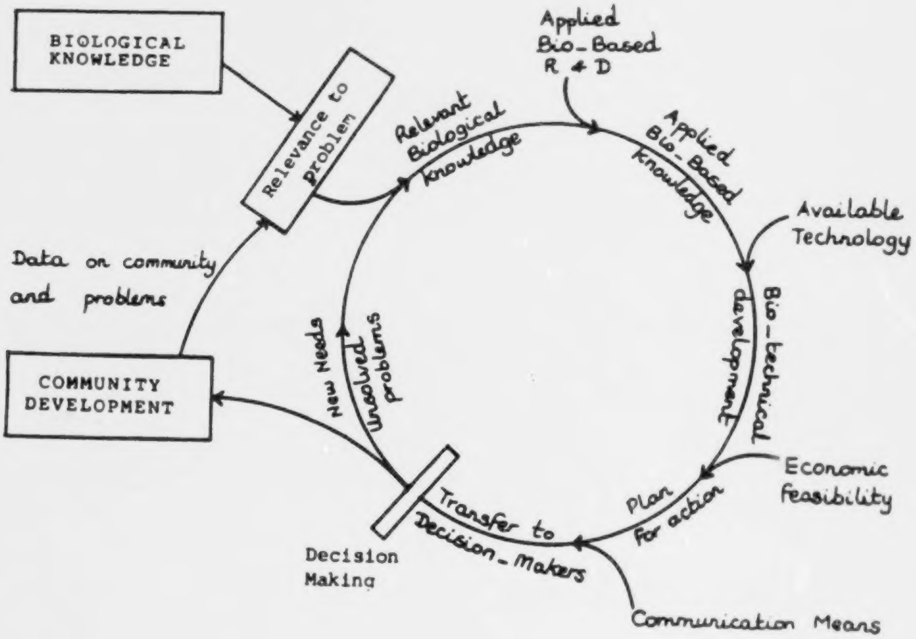
It is also important for biology students to appreciate the universality of change. Basic understanding of changes in biological systems can be used as a starting point for understanding socially oriented changes. These societal changes may be at personal, community, national or even international levels. The effective control of change is of central importance in ensuring a rational and meaningful approach to life.

Much problem solving follows Model A and this essentially involves trial and error so there is a hit or miss situation in regard to finding a solution. However it can sometimes resolve relatively minor disturbances. Model B is based on rationality and considered action and is more likely to lead to effective and lasting change.

The well known science educator Abraham Blum shows how a Havelock type rational problem solving approach can be used to apply biological knowledge to solve biologically-based community "disturbances" or problems. He has developed a model which he has called the "Biological Knowledge for Community Development Cycle". This model is shown below (15).

THE BIOLOGICAL KNOWLEDGE FOR COMMUNITY DEVELOPMENT CYCLE

(BLUM)


BIOLOGICAL KNOWLEDGE
Relevance to problem
Relevant Biological Knowledge
Applied Bio-Based R & D
Applied Bio-Based Knowledge
Available Technology
Bio-technical development
Economic Feasibility
Plan for action
Communication Means
Transfer to Decision-Makers
Decision Making
COMMUNITY DEVELOPMENT
New Needs
Unsolved problems
Data on community and problems

From the point of view of a biology teacher such models of change imply that school students should develop future-oriented problem-solving types of skills which would enable them to utilize the models in bringing about effective societal change. Professor Peter Kelly suggests that the qualities a student needs to cope flexibly with future changing circumstances are as follows (16).

(i) open-minded and scientifically honest attitudes;

(ii) an appreciation of the distinction between knowledge, conjecture, and opinion;

(iii) understanding of the social and ideological contexts of biological change;

(iv) understanding of probability, trends, extrapolation and other relevant 'statistical' concepts;

(v) understanding of ecological, evolutionary and other time-related biological principles;

(vi) lateral thinking in problem solving;

(viii) critical appreciation of the logic and conjectures of good science fiction authors.

According to Havelock individuals involved in change based on rational problem-solving can adopt various roles - which roles predominate, and which are most effectively applied, determine the outcomes of the change.

In the first place there are people who in various ways initiate change. These people behave in some way like chemical catalysts in that they may start a process, slow it down or speed it up. Such people often start off a change sequence by expressing dissatisfaction with a situation or by identifying a problem in any given situation. They stimulate action.

A second type of "change-agent" is a person who provides immediate answers to a problem. These are "solution-givers". Solution givers may have a deep insight into the nature of any problem and if so, can facilitate change. On the other hand they may offer inappropriate solutions and so unless their ideas are carefully evaluated and tested they can actually inhibit effective change.

An especially important role in change is to function as a "process" facilitator. Such people can apply techniques which help others identify needs; formulate problems; state objectives; formulate possible solutions; suggest ways of evaluating the effectiveness of alternatives and so on. They help people involved in the change implement the change rationally and effectively.

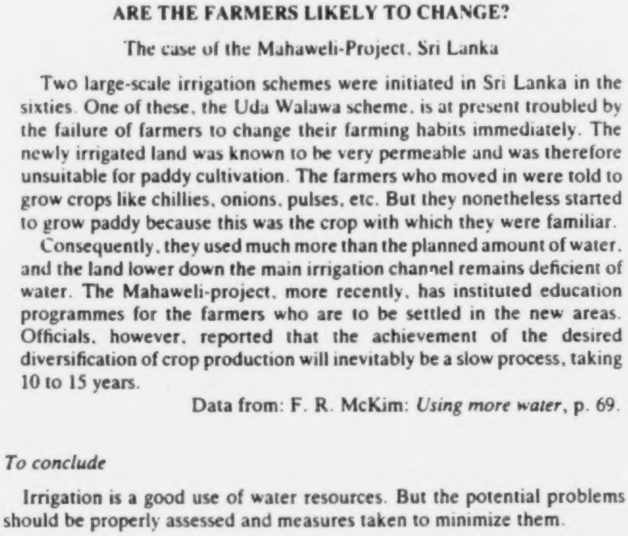
A further type of change agent could be thought of as a resource person who helps link together the human and non-human resources needed to bring about effective change. These resources include materials, personnel and finances. Havelock stresses, however, that the roles are not mutually exclusive and that any one person may play one or more roles at the same time.

In a socially oriented biology programme which deals with societal "change", therefore, a case study approach is advocated in which problem-solving processes such as those suggested by Havelock or Blum are pursued, and in which the personal characteristics advocated by Kelly, and the roles suggested by Havelock are made overt. Skills of problem solving and of the management of change should be made transferable by using case studies of direct relevance to the lives of students.

The examples of content given below provide suitable case studies for the type of analyses discussed above. None, however, involves a direct application of the change principles outlined. These applications are left to the initiative of the individual reader. Some ideas are presented in the section on Project and Test Questions.

ii) Examples of Content

Example 8.26: Changes in farming practice
School System: Sri Lanka secondary school science *Approach: Description of case study followed by conclusion and leading question* *Source: Van Aalst, Hans "Water Resources" in Graves, Norman Land, Water and Mineral Resources in Science Education (Science and Technology Education and Future Human Needs Volume 4). Oxford: Pergamon Press for the ICSU Press 1987) pp 127-141.*



ARE THE FARMERS LIKELY TO CHANGE?

The case of the Mahaweli-Project, Sri Lanka

Two large-scale irrigation schemes were initiated in Sri Lanka in the sixties. One of these, the Uda Walawa scheme, is at present troubled by the failure of farmers to change their farming habits immediately. The newly irrigated land was known to be very permeable and was therefore unsuitable for paddy cultivation. The farmers who moved in were told to grow crops like chillies, onions, pulses, etc. But they nonetheless started to grow paddy because this was the crop with which they were familiar.

Consequently, they used much more than the planned amount of water, and the land lower down the main irrigation channel remains deficient of water. The Mahaweli-project, more recently, has instituted education programmes for the farmers who are to be settled in the new areas. Officials, however, reported that the achievement of the desired diversification of crop production will inevitably be a slow process, taking 10 to 15 years.

Data from: F. R. McKim: *Using more water*, p. 69.

To conclude

Irrigation is a good use of water resources. But the potential problems should be properly assessed and measures taken to minimize them.

Example 8.27: National biogas project in India

School System: Indian secondary schools and adult education programmes
Approach: A brief summary of a case study which could lead to discussion questions on the management of change
Source: Mehta, S.R. "Assimilation of Technology in Rural India - an Educational Approach" in Waddington, D.J. Education, Industry and Technology (Science and Technology Education and Future Human Needs Volume 3). Oxford: Pergamon Press for the ICSU Press 1987 p 59.

National Biogas Project

A vivid example of the application of science and technology in our lives in India is the National Biogas programme, a programme which is making a large scale intervention into our traditional rural society.

As a result, millions of rural people will come into direct contact with a new technology which will confront them with scientific ideas in opposition to long-held beliefs and prejudices. This is a challenge to those who are developing science and technology curricula for schools. However, the programme itself can become one of the examples of the ways in which we can educate our future citizens.

As a first step, we have broken down the scientific and technological principles involved in the building and use of a biogas unit — in terms of the Gujarat State Higher Secondary School Examination.

Further, we are developing simple experiments to produce biogas and examine its properties and we wish it, too, to have a technical bias so that students gain experience in simple work with wood, metal and bricks in making a unit. This is one example in a programme for introducing rural technology into our schools and showing its relevance to today's needs.

Example 8.28: Water resource development in India

School System: Indian secondary schools
Approach: Detailed case study of a major developmental project in India. Review of impact and management of change
Source: Vedanayagam, Edith "Periyar-Vaigai Project - a Case Study" in Graves, Norman Land, Water and Mineral Resources in Science Education (Science and Technology Education and Future Human Needs Volume 4). Oxford: Pergamon Press for the ICSU Press 1987 pp 162-165.

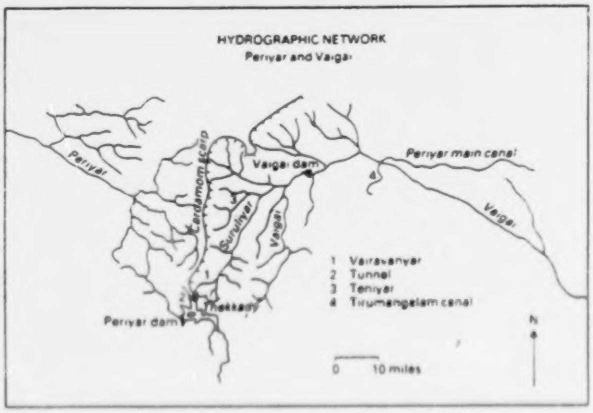


Fig. 8.7

2. (a) What are the major functions of a dam built across a river.
   (b) List the arguments for and against the location chosen for the dam. These may be hydrological, societal or geographical.
3. Discuss the drawbacks of the irrigation system during the pre-Periyar period. How have they been improved during the post-Periyar–Vaigai period? What do you think are some of the disadvantages of an irrigation system?
4. Discuss the benefits that have stemmed from the Periyar–Vaigai Project, with special reference to Jothimanickkam village of the project area?
5. Farmer John has four plots of land scattered over the village land. How does he manage to irrigate all these plots? If they were adjacent, what would be the advantages?
6. Study Fig. 8.8, the land fragmentation of Jothimanickkam village. How does it affect agricultural development of the village? Discuss ways of minimizing fragmentation of land.
7. If you were to live in Jothimanickkam village, what would be the outcome of the project that you would benefit from most?

Teaching strategies

The teachers may use the unit on Periyar–Vaigai project – a case study, in the following ways:

Periyar–Vaigai project – a case study

EDITH VEDANAYAGAM

Overview of the instructional module

The teaching module, Periyar–Vaigai project presents a case study of a water resource development scheme in South India, which has resulted in raising the agricultural output in the project region. The special feature of this project is the diverting of the waters of a west flowing river eastward to irrigate the parched lands of the Madurai plains. A mini case study of a farmer in a village in the project area is presented to illustrate the benefits derived from this project.

Objectives of the study

To enable the students:

1. To understand the concept of the diversion of river waters of one river to the other, taking advantage of appropriate physical facilities.
2. To comprehend the reasons behind such a diversion.
3. To appreciate the engineering efforts taken and the difficulties surmounted for diverting the waters, during the end of the 19th century, with the limited technology of that time.
4. To study the significance of the climatic conditions and the relative effects on both sides of the water divide (Cardamom Hills).
5. To compare the land utilization and cropping patterns of the pre and post Periyar periods.
6. To see the relationship between the irrigation patterns followed in South India and that of the student's own country.

7. To understand the problems related to land fragmentation in a village such as Jothimanickkam.
8. To comprehend the benefits of Periyar–Vaigai project to farmers in the Madurai plains.

Activities for the students

A map of India (or South India) is essential to the study of this module, preferably a physical map. If a small scale map (1:1,000,000) of South India is available, it will be very helpful in understanding the physical environment of the project area. Further, Fig. 8.8 shows the fragmentation of land in a village – the agricultural land of 164 hectares has 548 fragmented plots owned by 89 people. The students may be encouraged to carry out the following activities after going through the module.

1. Study Figs 8.6 and 8.7 in relation to the map of India or South India and:
   a. Distinguish the main features of the terrain and the rivers.
   b. From a rainfall map indicate the distribution of rainfall in the area.
   c. Outline the factors that contributed to the diversion of the waters of the Periyar river to the Vaigai river.
   d. Indicate the difficulties that were surmounted in the construction of Periyar Dam.

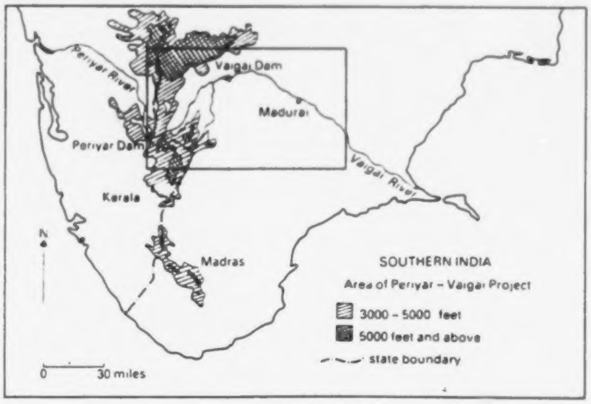


FIG. 8.6

1. Considering the unit as an instructional module, the class of students, preferably at the secondary level, can be introduced to the unit by displaying maps of India or South India and the enlarged maps in the unit, especially Figs. 8.6 and 8.7. After a discussion of water resource development in general, the teacher can introduce the Periyar–Vaigai project itself. With a clear idea of the project, the students can be encouraged to read on their own the mini case study of a farmer and then carry out the suggested activities.
2. The whole unit can be considered as a self-instructional module. With the help of the maps, diagrams, transparencies and slides, the students can study the unit, the teacher giving the needed guidance.
3. The unit being a case study in water development schemes in a developing country, the teacher can handle the unit as a case study, moving from the particular to the general.
4. The unit can also be used as a mini course to develop certain learning skills such as skill in the use of maps, skill in enquiry, skill of questioning etc.

BEST COPY AVAILABLE

Example 8.29: The Oberwart Waste Project

School System: *Austrian Federal Commercial Academy*
Approach: *Account of a school initiated community change project about the effective disposal of waste*
Source: *Federal Commercial Academy Oberwart "The Oberwart Waste Project" in OECD International Project Exhibition "Cycles" "The Daily Life of the Family M" (OECD Project Environment and School Initiatives). Vienna: OECD/CERI and the Austrian Federal Ministry of Education, Arts and Sports in Cooperation with the Upper Austrian School Board 1988 pp 102-104.*

The Oberwart Waste Project

In a circular letter, the students of the Federal Commercial Academy Oberwart started a 'Waste Project'. Effective actions soon followed, and an end to the project is not yet in sight.

THE WASTE DETECTIVES FROM THE BURGENLAND

'For many today, the preservation of the environment has remained lip service. Hardly anyone wants to admit that he himself has to be considered as a causative factor of environmental problems and that waste is also of his own making...'

This is the sentence which introduces a documentation of the BHAK (Federal Commercial High School) Oberwart. This school has been working on a waste project started within the framework of its geography studies since 1984. In painstakingly detailed work they have tracked down illegal dumps in the district of Oberwart, drawn up a cadastral map, evaluated results and established contacts with local authorities, politicians and ministries.
They succeeded in assembling representatives of all leading offices of the Burgenland around one table for consultations with the result that these representatives agreed to cooperate and to attempt to find solutions jointly.

IT ALL HAD STARTED WITH A LETTER

The first activity of the group of pupils was to send a letter to leading politicians and corporations in which they pointed to the sad situation of our environment and concluded by asking two questions:
'What ought we to do against it in the near future?' and 'What will you do against it?'
Fifteen of the sixteen letters mailed were answered. To a large extent these answers were positive and friendly, large corporations also partly tried to explain their 'ecologically harmful' activities. In the course of this activity the pupils were also invited to Vienna for a discussion with the mayor of Vienna, Dr. Helmut Zilk. Also the media reacted altogether positively and by this already supported the project.

DRAWING UP A CADASTRAL MAP OF WASTE DEPOSITS

But the letter alone was of course only a start. The pupils organized exhibitions and discussions dealing with the topic 'Preservation of the Environment'. The fact that there are so many illegal dumps came more and more into the foreground. The pupils of the BHAK Oberwart decided to draw up a cadastral map listing the deposits in the district Oberwart.
In the holiday months July and August 1985 they hiked through the region, looking for illegal dumps, and they also found them. Dumping old tyres, plastic cans, debris of building sites, empty tins and other waste is not only a form of visual pollution, but can also be dangerous. One litre of motor oil can render up to one million litres drinking water undrinkable!

90 ILLEGAL DUMPS

So far, the group, supported and led by the headmaster of BHAK Oberwart, Karl Schweitzer, has already found 90!!! such dumps only in the Oberwart district. It is anything but a delightful prospect, if we consider the size of the district Oberwart compared to all of Austria and have to assume that many more dangers are lurking on the entire territory in the form of illegal dumps!

In cooperation with the authorities concerned some of these dumps were cleared, i.e. the waste was removed from these dumps and the dangerous substances were either burnt in suitable waste incineration plants or deposited on suitable deposits for special waste.

WHO OF US HAS AN AWARENESS CONCERNING WASTE?

But this was not yet enough for our young private eyes on 'waste'. They tried to get to the root of the problem, to find the causing agents - and that is all of us. With the actions that followed they tried to change the attitude of the population, to stimulate people to think and to come to the conclusion that pollution can already be reduced by very simple means, e.g. by collecting waste separately according to material. The conscious purchase and use of household cleaners, paints, varnishes and detergents can reduce the amount of toxic matter presenting a threat to the environment.

SETTING THE COURSE FOR A LARGE PROJECT

On the occasion of 'Environment Action Day' held in Oberpullendorf on June 25, 1986, the course for a large project 'The Waste Project Oberwart' was set together with the Labour Market Board and adult education institutions.
The objectives of this project are the decontamination and removal of waste from all illegal dumps in the district Oberwart (in cooperation with the Labour Market Board and the Burgenland Waste Association) and separate collection of waste in a large housing estate. The publication of an ecological newspaper was decided as well. The ecological awareness of the population is to be changed by lectures and discussions; in addition, the public is to be made aware of the sad state of our environment, to be informed about what they can do against this situation.
With the support of the Labour Market Board, waste consultants are being trained who can provide information on the dangers lurking in household waste and on how to avoid these toxic agents.
Gradually the 'Waste Project Oberwart' is developing into a pilot project for other districts of the Burgenland. The group is also invited to present its project in Graz, since similar activities are planned for Styria.

In February 1987, a workshop on the subject 'Protection of the Environment' took place in the secondary modern school of Friedberg, leaving the pupils greatly impressed. This was followed by further discussions and information meetings in the Burgenland.

THE IDEALISM OF BHAK OBERWART SHOULD SERVE US AS EXAMPLE

The pupils of BHAK Oberwart managed to put their ideas into practice and to implement their plans. They continue developing new ideas and muster the energy to see them through. Their repeated presence in the media also bears testimony to the importance of the actions of the group.
All this is only a flash in the pan, and we are well aware of this fact, but it is up to us to preserve a world worth living in. The group of pupils has contributed essentially towards increasing our awareness of the fact that time is almost running out and that we all have to think very carefully about ways and means to protect our environment from even greater damage.
(Klaudia Erben)

THROWING IT AWAY IS NO SOLUTION

What everyone of us can do to protect our environment:

- Waste paper such as telephone directories, cardboard and packaging material are not part of household waste but should be collected.
- Similarly glass can be collected separately, divided into white and coloured glass; metals, such as tins, tubes, old tools and discarded cooking utensils, beverage cans and old textiles can be recycled.
- In no case may drugs, empty batteries, residues of varnishes, motor oils or pesticides be thrown carelessly into household waste or even be dumped in Nature.
- Ecologic awareness starts with shopping. People with this attitude will buy bottles instead of cans, water-soluble paints and varnishes, which are comparatively non-toxic, instead of highly toxic ones. All these measures can reduce the amount of toxic material in waste considerably.
- Household cleaners such as window and toilet cleaners can be simply and effectively replaced by vinegar. As far as detergents are concerned, one should carefully observe the indicated dosages. More detergents do not make your laundry any cleaner.
- In Vienna, comprehensive research and drives on the subject 'collecting waste separately depending on the material' were launched over the last few years. In some districts of Vienna there are already so-called 'waste material centres' with containers for white and coloured glass, scrap metals, beverage cans, waste paper and waste textiles. In addition, every district of Vienna has special collection points for 'problem material' where material such as e.g. batteries, drugs, fluorescent tubes, toxic material of any kind, chemicals and even car batteries can be handed in. In 1987, 60 000 people either brought such material to these points or asked chemists for advice.

By separating waste, the amount of waste could be cut in half. This applies to toxic waste and to waste amounts for which waste dumps have already become too small.

iii) Examples of Project and Test Questions

. Project. Qualities of an effective change agent. When you leave school, you will be involved in all kinds of personal, family and community situations which will involve some change in your life or in the lives of others. Most of these changes will come about because of problems which crop up in your day-to-day life. Many of these problems will have some link with biology.

Some people have suggested that in order to be successful in solving the problems of life you must have certain qualities and interests. These qualities and interests are listed below. For each quality rate yourself 4, 3, 2 or 1 as follows

4 = Very good. I'm like that a lot.
3 = OK but room for improvement.
2 = Not too bad but I would need to work on that.
1 = Not much like me. Lots of improvement needed.

Quality	Rating (4, 3, 2 or 1)
1. I'm pretty much open minded about most things	____
2. I believe science reveals the truth about most things	____
3. I can easily tell the difference between knowledge, guesses and opinions	____
4. I can tell if some biology is involved in changes occurring in society	____
5. I'm pretty good at estimating probabilities and at identifying present and future trends	____
6. I understand that many concepts in biology such as ecology and evolution involve changes over time	____
7. When I'm trying to solve a problem in my life I think very broadly and widely about it	____
8. I enjoy reading good quality science fiction because of the interesting ideas and logic of the arguments	____

How did you rate?

What could you do to improve those qualities on which you gave yourself a low rating (ie. 2 or 1)?

Source: Suggestion by author based on the qualities suggested by Professor Peter Kelly listed in section 8.6(i)).

- Project. Metro Manila sewage disposal. Read the following account of a sewage disposal project and then answer the questions which follow. You may form discussion groups of 4 or 5 to review the questions.

> The National Pollution Control Commission (NPCC) estimates that about 60% of the total water pollution load in Metro Manila comes from municipal sources, and this is due to the absence of sewerage systems in most parts of the city. In response to this problem the Metropolitan Water and Sewerage Service (MWSS) has embarked on a 20-year wastewater system program through the Metro Manila Sewerage Project.

To reduce water pollution within the city, the project plans to divert the polluted effluents from the water bodies to Manila Bay. This is to be accomplished by installing additional sewers and service connections where wastewater will be connected, to be discharged from disposal points - the North sewer outfall, near Navotas; South sewer outfall, near Paranaque area; and the Central sewer outfall, the outfall being used now in North Port Area. This project does not yet include chemical treatment of the wastewater. It depends only on diffusion and dilution of wastewater as it flows into the Bay. It is expected that the wastewater would have been processed by the time it reaches the Bay. It is also presumed that this would not adversely affect the ecological balance in the Bay area.

(a) What is the problem outlined in the article?

(b) What agency started the process of change?

(c) What solution has been proposed?

(d) What assumptions have been made about the success of the project?

(e) How could the assumptions be tested (i) before the project starts and (ii) after the project has been completed?

Source: Suggestion by author based on case study in Institute for Science and Mathematics Education Development (ISMED) University of the Philippines. Let's Stop Water Pollution Now Part 2 (Environmental Chemistry Series). Manila: ISMED 1987 p 82.

. Project. Facts versus opinions in determining a social policy.

Biased Opinion About the Use of Land

Most decisions concerning land use are based on facts. However, two people may look at the same fact, interpret it differently, and draw different conclusions. Consider, for example, the Congressional elections. One year, the Democrats lose 12 seats in the House of Representatives to the Republicans. After the election, the makeup of the House is 255 Democrats and 180 Republicans. Those are the facts.

The day after the election, the chairperson of the Republican party states, "Our party has made tremendous gains and the people of the United States are turning away from the policies of the Democrats." On the same day, the chairperson of the Democratic party says, "The party is extremely healthy because there are 255 Democrats in the House of Representatives. The people of the United States still believe in the Democratic party because the majority of representatives are Democrats."

These two people see the same fact, but they draw different conclusions. Neither chairperson is necessarily wrong; each just happens to "see things in a different light". How can you tell when someone's biased opinion is clouding the facts? When you receive information about an issue, find out the source. Does the source have a vested (personal) interest in the issue? Could there be a reason for a distortion, however slight, of the facts? For example, you might expect the chairperson of a political party to interpret the facts favourably for his or her party.

Also, make certain that you obtain information in the proper context. For example, suppose someone told you that he or she was in a test group that used a certain toothpaste. That group had 15 percent fewer cavities than another group that did not use the toothpaste. That sounds like an excellent recommendation for the toothpaste. But what if the first group was 15 percent smaller than the second? Or, what if the first group also stopped eating candy, but the second group did not? Because of these additional facts, do you see the original fact differently?

Check all the sources of information available to you. In a land use issue, for example, ask different people about the land an how it will be used. Separate the facts from the opinions. With a great variety of information on the issue, you will be less influenced by the bias of others. And it will be easier for you to form an objective opinion.

How can you be sure that your own bias is not influencing your decision? Stop for a minute and ask yourself:

1. Have I thought of all the positive and negative consequences of this issue?
2. Have I stated my own opinion or am I just voicing the opinion of another person?
3. Have I considered all the facts that are relevant to the issue?

When making decisions, weigh facts against opinions. Consider the biases that might have influenced the presentation of these facts and opinions.

Source: Biological Sciences Curriculum Study (BSCS). Investigating the Human Environment: Land Use. Colorado Springs: BSCS 1984 pp 11-12.

. Project. School children's initiative in bringing about effective change. Read the following extract from an article in the Sunday Times of 23rd October 1988.

Form discussion groups of 4 or 5 to review the questions given below the article.

> Children from a Norwegian primary school went round their neighbourhood recently asking mothers whether they used a detergent laced with phosphates.

When the answers came back - typically "Don't know" and "What does it matter anyway?" - the junior researchers patiently explained that the purpose of the chemical additive was purely cosmetic and that when the suds were rinsed away, they helped to promote the multiplication of potentially harmful organisms in the community's water. The result: a significant change in the shopping habits of one Oslo suburb.

But the youngsters did not leave it at that. They went on to approach detergent firms and successfully persuaded one to start manufacturing phosphate-free washing powders. Their campaign, telling people that powders claiming to wash whiter do no more than reflect the light so a shirt looks whiter without necessarily being cleaner, had clearly paid off. The children urged all shoppers to read the contents labels on the packets and bottles carefully. And they told housewives "make sure they are biodegradable".

(a) What biology topics do you think may have triggered the children's interest in detergents?

(b) The children conducted a survey of parental opinions. What was the objective of the survey and what methods did the children use?

(c) The detergent project brought about certain changes in the community. What were these changes?

(d) How could you check up whether or not the changes were long lasting? What was the main purpose behind bringing about these changes? How could scientists check on whether that purpose had been achieved?

Source: Questions suggested by author. Stimulus material Izbicki, John "Children Take the Lead in Clean-up" in Sunday Times 23 October 1988. Provided by Kathleen Kelley, Project Officer OECD Environment and School Initiatives. Paris November 1988.

. Test Questions

(1) When biological knowledge is used to bring about changes for the improvement of community welfare, action is frequently triggered by scientists or others trained in biology. This is because they can identify the relevant biological knowledge which can be used to improve the situation.

   (a) Give an example of a community situation which could be improved by the application of biological knowledge.

   (b) Give an account of how this situation might be or has been improved.

(c) How could you check whether or not the solution has had the right effect in (i) the short term and (ii) the longer term?

(2) Read the following article by Father P. Tempels who worked in the Congo area of Africa (now Zaire) for many years.

> In common with so many others, I used to think that we could get rid of Bantu 'stupidities' by suitable talks on natural science, hygiene, etc., as if the natural sciences could subvert their traditional lore or their philosophy. We destroy in this way their Natural Sciences, but their fundamental concepts concerning the universe remain unchanged. An example will make this point clear. How many times have we not heard an African accused of being the cause of an illness, even of death, of some other person simply because he had a dispute with him, or because he had insulted or cursed him? There is the usual palaver. The accused accepts judgment. He pays the damages claimed from him, usually without much argument and even, sometimes, in spite of the contrary judgment of a European Court. For the Bantu, indeed, the palaver judgments are clear and indisputable. They have a different conception of the relationships between men, of causality and responsibility....If thereafter we wish to convince Africans of the absurdity of their sizing up of the facts by making them see how this man came to fall sick and of what he died, that is to say by showing them the physical causes of the death or of the illness, we are wasting our time. It would be in vain even to give them a course in microbiology to make them see with their own eyes, or even to discover for themselves through the microscope and by chemical reactions what the 'cause' of the death was. Even then we should not have settled their problem. We should have decided only the physiological or chemical problem connected with it. The true and underlying cause, the metaphysical cause, would none the less remain for them in the terms of their thought, their traditional wisdom.

(a) Do you agree with the use of the word "stupidities" in the first sentence? Justify your answer. [½ page]

(b) In what ways does this story highlight the problems for someone coming from "outside" a particular cultural group in trying to bring about a change in that culture? [2 pages]

(c) How could traditional beliefs and practices be used as a starting point for bringing about effective lasting change in the way of life of people like the Bantu? [2 pages]

Source: Suggestion by author based on a quotation from Tempels, P. Bantu Philosophy. Paris: Présence Africaine, 1959.

(3) Your school wishes to establish a recycling depot for used clothing, paper and bottles.

(a) What information would you need before you could start the project? How could you get this information?

(b) How could you find out whether or not the depot is working:
(i) in serving the needs of the local community?
(ii) in working efficiently to recycle the waste?

(c) Set out a short plan of action to get the project started. Draw up a table showing what should be done, by when it should be completed, whom should be responsible for each step and what resources you would need to complete each step.

Source: Suggestion by author

(4) In bringing about changes of importance to the local community it is probably best to work as a team. Some people are good at working out just what is wrong and making it clear what should be achieved. Other people are good at gathering information, money and material and the help of various people. Other people are especially good at helping the team work well. They set clear goals, can advise on finding solutions and can help the team check up on whether they are going about the task in the best possible way.

Choose a situation in your local community which should be changed and which has some relation to biology. This could be a situation involving water pollution, disposal of household garbage, a transport matter or some medical issue. You may think of something else.

Write an essay on how a team of about five or six students from your school could work with the community in improving the situation. What types of jobs could the various members of the team be assigned?

Source: Suggestion by author.

(5) A small zoo in a big city is short of money and the management committee holds a meeting about how to raise funds.

> John says: "We should raise the entrance fee".
> Mary says: "Perhaps, but I don't think that is enough. We should work out a plan to solve the zoo's financial problems".

What is the difference between the suggestions made by John and by Mary?
If Mary's idea is accepted what should the zoo do to find solutions to its financial problems?
[Write about four pages]

Source: Suggestion by author.

8.7 Critical Societal Concerns

i) Rationale

The general change in emphasis in biology teaching from knowledge based studies to studies of social issues has already been discussed in Chapter 2 Section 2.2(k). Throughout Chapters 6 and 7 and in this chapter many examples have been given already of how biology can be applied to analyse and review social issues. In particular aspects such as personal development, human dignity, population and environmental studies, bioethical matters, equal opportunity and the study of "change" all involve social issues. Many of these issues have involved conflicting viewpoints and values and have necessitated teaching approaches involving training in objective analysis, values clarification and conflict resolution.

This section, therefore, assumes a sensitivity towards dealing with social issues. It takes a major step forward by considering how biology teaching may help resolve, or at least moderate, those major social concerns dominating the lives of a particular community or even nation. While no-one would be foolish enough to claim that a course in school level biology could in itself do much to resolve these major concerns, it can make its contribution along with the contributions of all other subjects of the curriculum across all levels and categories of the educational system.

The following table lists some examples of the concerns dominating the fabric of society in selected countries. The table also suggests what biology teachers could do to help educate people about these concerns by providing deeper understanding, tolerance and an attitude of willingness to help resolve the problems involved and to moderate their negative impact.

Examples of Critical Societal Concern in Selected Countries

Country (Anon)	Region or Sub/Region	Critical Concern	Suitable topics or approaches in biology
A	South Pacific	Drug related crime	Effects of drugs on physiology Economic aspects of drug abuse
B	South Pacific	Breakdown of law and order in cities	Human dignity Personal growth Conflict resolution Resource planning
C	South Asia	Insurrection by political and religious minorities	Individual differences Cultural evolution Cooperative behaviour Conflict resolution
D	East Asia	Drug abuse by youth	Effective use of leisure "Physiology" of drugs Behaviour modification
E	SE Asia	Social inequity due to unequal ownership of land	Management of resources Land use studies Studies of interdependence Personal growth Human dignity
F	East Asia	Human population explosion	Population ecology Resource management Family planning
G	Eastern Europe	Economic problems involved in changing to a free market economy	Entrepreneurship in biology-based employment Biology-based careers

H	Northern Europe	Environmental concerns about acid rain from neighbouring countries	Pollution studies Environmental managment
I	Atlantic Island	Economic problems due to overfishing	Marine ecology Resource management Economic aspects of fishing industry
J	Sub-Sahara Africa	Poverty due to scarcity of resources	Resource generation Income generating activities (biological) Search for alternatives (eg food, energy)
K	Southern Africa	Social tension due to racial confrontations	Biology of race Human evolution Cultural evolution Conflict resolution
L	Latin America	Social instability due to political extremism	Conflict resolution Individual differences Cultural evolution Aggression (behaviour)
M	North America	Unequal distribution of wealth	Resource management Individuality and personal growth Employment opportunities through biology

In some cases the biology teacher may achieve little more than heightening awareness or improving understanding through objective and unbiased analysis of situations. In other instances there may be a direct contribution to some moderation of the concern by improvement in necessary knowledge and skills needed to cope with the underlying problems at the basis of the major concern. In all cases of course the entry point should be the societal concern. Transfer will not occur unless the linkage between the social situation and the biology is made overt.

Teachers using biology in this way should make considerable use of the mass media - especially newspapers and magazines. An analysis of the media shows how the concern dominates the society; how it affects the way of life of all citizens and how it impacts on the wellbeing of the nation as a whole. The biological bases of the area of concern should be examined and case studies should be selected of specific instances of its impact. The aim should not just be to help school leavers live more equitably in the face of the societal problem, but to make their contributions as citizens towards its resolution.

Few examples are available of such a direct societal role for school biology. The examples given below, however, are intended to show how some programmes are attempting to include at least some aspects of this approach.

ii) Examples of Content

Example 8.30: Trade-offs - values analysis

School System: USA secondary school science

Approach: While this example does not address a central concern for a whole nation it provides an interesting example of how to analyse values relevant to such concerns

Source: Biological Sciences Curriculum Study (BSCS) Investigating the Human Environment: Land Use. Colorado Springs: BSCS 1984 pp 12-13.

Trade-Offs

How is it possible to deal with the many consequences of an issue? Are all of them equally important? Or is one consequence more important than another? For example, a factory in your neighborhood may mean more jobs for the people there. But it could mean more noise and pollution for these same people. Which is more important—a job or a clean, quiet environment? Is this really an "either/or" situation?

How can we deal with opposing views and *trade-offs?* A trade-off results when something negative and something positive happen at the same time, such as pollution and jobs. Another example is paying money for something you want. Just how much are you willing to pay? One way to deal with this trade-off problem is with a values analysis.

To set up a values analysis, place all the positive and negative consequences of an issue on the same chart or table. In our example, two of the consequences of building a bicycle factory in your neighborhood would be jobs (positive) and pollution (negative). Assign a point value to each consequence according to how you feel about it. The higher or lower the point value you place on the consequence, the more strongly you feel about it. If you feel the consequence is very positive, give it a score of +10 points. A score of +3, however, would indicate you feel the consequence is good but not as important. If you feel the consequence is very negative, give it −10 points. A "0" rating indicates you are not sure about the consequences. Use Figure 2, Values Analysis Scale, to assign values to each consequence.

−10	−9	−8	−7	−6	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
	very negative			negative				slightly negative		don't know		slightly positive			positive				very positive	

Figure 2. Values Analysis Scale

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Values Analysis
Land Use Issue: Should the vacant lot in the downtown area be converted to a parking lot?

Positive Consequences	Value	Negative Consequences	Value
1. The vacant lot is unsightly and the parking lot will clean that up.	+3	1. Cars will cause traffic jams entering and leaving the parking lot.	-3
2. The parking lot will draw more customers to downtown businesses.	+8	2. People will not ride the bus. They will use their cars, and the air pollution will increase.	-10
3. The parking lot will create jobs for parking attendants.	+5	3. More traffic means more accidents.	-7
4. The parking lot will reduce the stress of looking for a parking space.	+2	4. The parking lot pavement will absorb heat in the summer and make the city hotter.	-1
Total	+18	Total	-21

Jane Cummins
Name

Figure 3.

Total both values columns. Then add these two totals. A positive total score indicates you should decide in favor of the issue. A negative total score suggests deciding against the issue.

Let's use another example to demonstrate how the Values Analysis Scale works. Suppose you were to help decide whether the vacant lot in the downtown area of your community should be turned into a parking lot. Your values analysis might look like the one in Figure 3. According to Jane's analysis, she would reject the suggestion to build the parking lot. She has more minus points than plus points.

Not all people would agree with the point values Jane assigned to each of the consequences. A business person in the downtown area might have given a +10 rating to the second positive consequence. A traffic officer might have given the third negative consequence a −10 rating. And if you needed a job after school, you might have rated the third positive consequence higher.

This analysis reflects one person's opinion about an issue that concerns many people. And it should make you think about your own values. Which consequences do *you* consider to be more important in making the decision?

Example 8.31: The drug problem in Hong Kong

School System: *Hong Kong secondary schools and adult education programmes*
Approach: *Background notes for teachers. Note especially paragraph 4 which could provide entry points for teachers of biology*
Source: *Government of Hong Kong The Drug Problem in Hong Kong (Summary of a script for the slide show). [Note: slightly abridged]. Hong Kong: Government Secretariat Narcotics Division March 1986 (Availability courtesy of Hong Kong Ministry of Education).*

The Drug Problem in Hong Kong

Drug abuse is a serious social problem. From the information collected by the Narcotics Division of the Hong Kong Government, it is estimated that among the 5.5 million population in Hong Kong, about 50,000 people are involved in drugs.

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2. Among the drug abusers, a small proportion abuse opium, marijuana and non-opiate psychotropic substances; the rest, over 96%, abuse heroin.

3. Most of the abusers first tried heroin in their early teens. The most common causes of drug abuse are thought to be:

(a) Curiosity. Driven by curiosity, teenagers are tempted to experiment with drugs.

(b) Peer group pressure. It is not uncommon for youngsters to abuse drugs as a result of influence and pressure from their peers.

(c) A small proportion of youngsters mistakenly believe that drugs may enhance their sexual potency. However, once a person is addicted to drugs, he will lose interest in all other things except drugs.

(d) Young people, when they meet with a reversal such as failure in an examination or when they fall out with their parents, may resort to drugs as a means of escape from reality.

(e) Some teenagers believe, wrongly, that advanced medical technology can provide a certain cure for drug addiction, and therefore think that they can abuse drugs without danger to their future well being.

(f) Some teenagers may think, wrongly, that they may not succumb to drug addiction. They think that as long as a person has a strong will-power and determination, he will not become addicted. In fact, no matter how strong-willed and determined a person is, if he takes heroin, he will soon become addicted.

4. The harmful effects of drug abuse may be seen from three perspectives. From an addict's personal point of view, the most obvious and immediate effect is his total dependence on the drug and pain and distress he experiences during withdrawal. Heroin addiction causes loss of appetite, leading to malnutrition and poor physical health. There is a high risk of fatal tetanus infection and death from overdose. Drug addicts are more prone to suicide than other people. The health and personality of a young person addicted to heroin deteriorates to such a state that it can break the hearts of his parents. If an addict is married, addiction to drugs will surely ruin his family life, forcing his wife and children to leave him out of despair. An abuser is unable to secure stable employment because of his addiction, and the only way to obtain money to buy illicit drugs to satisfy his craving is through illegal means such as robbery. Not only does the community lose an able body, law and order is also at risk.

5. The Hong Kong Government pursues a vigorous coordinated programme in fighting against drug abuse and is advised in all aspects of the programme by the Action Committee Against Narcotics (ACAN), whose executive arm is the Narcotics Division of the

Government Secretariat. The overall strategy has four main elements - law enforcement, treatment and rehabilitation, preventive education and publicity, and international action.

6. Law enforcement is the responsibility of the Royal Hong Kong Police Force and the Customs and Excise Department. For major offences such as trafficking in dangerous drugs or their manufacture, the maximum penalty is life imprisonment and a fine of HK$5 million.

7. Treatment and rehabilitation are mainly undertaken by the Medical and Health Department, the Correctional Services Department and the Society for the Aid and Rehabilitation of Drug Abusers (SARDA). The Medical and Health Department offers at a nominal charge out-patient methadone treatment to any heroin addict who requests it. The Correctional Services Department operates a compulsory placement programme for addicts convicted of criminal offences while SARDA, a voluntary agency, provides voluntary inpatient treatment.

8. Preventive education and publicity work rests with the Narcotics Division of the Government Secretariat, the Information Services Department, Radio Television Hong Kong, and the various district offices of the City and New Territories Administration. The work embraces a wide range of activities including publicity through the mass media, posters, leaflets, seminars, enquiry services and other local community publicity activities.

9. In order to prevent young people from experimenting with and abusing drugs, the Narcotics Division makes every endeavour to educate them with regard to the dangers of drug abuse. The ACAN Youth Volunteer Group provides an opportunity for young people to work together and assist in, or organize, campaigns and publicity activities to promote the anti-narcotics message.

10. The Narcotics Division also arranges anti-narcotics talks in all secondary schools in Hong Kong and operates a Youth Against Drugs Scheme (YADS). Through this Scheme, young people can form themselves into groups of not less than 10 persons and organize anti-narcotics activities which are funded by the Government.

11. The Hong Kong Government maintains close liaison with anti-narcotics agencies and organizations all over the world. It cooperates with Interpol in exchanging intelligence on international drug trafficking activities. A close relationship is maintained with overseas agencies engaged in research on the treatment of addiction.

12. In summary, the aim of law enforcement is to reduce the supply of illicit drugs by combating drug trafficking activities; the aim of treatment and rehabilitation together with preventive education and publicity is to reduce the demand for illicit drugs as well as to assist drug abusers to start a new life and to prevent young people from ruining their lives by falling prey to drug pedlars.

Example 8.32: Skills development for resolving issues of societal concern

School System: Hong Kong educational system
Approach: A tabular list of skills and suggested activities to equip learners for involvement in situaations of societal concern
Source: Education Department Hong Kong Guidelines on Civic Education in Schools. Hong Kong: The Curriculum Development Committee of the Education Department August 1985 pp 55-56.

Skill development activities

3.14 All learning activities promote, in one way or another, the development of skills, particularly the skill of acquiring, organising and using information together with those personal and interpersonal skills which are necessary for effective social participation. Pupils should be given ample opportunity to develop these skills through a balanced programme of activities which are attuned to their intellectual and social needs. The following checklist is designed to help teachers achieve a balanced programme for skill development :-

(a) Skills related to acquiring, organising and using information

Skills	Examples of activities
Finding information	Use various parts of a book; get information from pictures, photos, objects etc.
Classifying information	Identify relevant factual material; group data in categories; place events in sequence etc.
Interpreting information	State relationships of things; note cause and effect relationship; predict likely outcomes based on factual information

Synthesizing information	Present information visually (chart, graph, diagram etc.); communicate information orally
Decision-making (identify problem, generate alternatives, predict consequences, make decision and implement decision)	Project work, case study

(b) Skills related to interpersonal relationships and social participation

Skills	Examples of activities
Personal (express personal convictions; talk about own beliefs and feelings)	Role-playing; discussion
Group interaction (contribute to the development of a supportive climate in groups; participate in group activities as a leader or follower; participate in making rules for group life)	Simulation and role-playing; discussion
Social participation (identify situations in which social action is required; accept and fulfil social responsibilities)	Project work and case study on social issues; participation in community activities such as "Clean our beaches" or "Clean our country parks" campaigns

Example 8.33: Needs study in Mauritius

School System: Mauritius secondary schools biology

Approach: An edited extract from a report of a needs study of two local communities in Mauritius. The central national concern in this small island country is overpopulation. The social consequences of this include limitation of access to employment, education, health services and other facilities and resources. The needs analysis suggested ways the school biology programme could address this concern

Source: Atchia, Michael "Assessment of Community Needs in Mauritius - The Gap Between Commonly Believed and Actually Expressed Needs" in Atchia, Michael Research in Community-Based Biological Education. Chelsea: IUBS-CBE 1982 pp 104-124.

Background Information

The island of Mauritius has often been described as a microcosm of humanity, having within an area of 720 sq. miles, people of different religio-cultural backgrounds, ranging from Hinduism and Buddhism to Islam, Christianity and pantheism - all this based on the three major racial groups, namely caucasian, negroid and mongoloid. Over and above these differences and divisions there has established itself an extremely clear, local, Mauritian culture, which in its origin, composition and nature, has been compared to that of huge Brazil. Furthermore, from sea-level to the centre of the island (a maximum distance of 45 km), a variety of micro-climate and ecosystems are to be found, accompanying, so to speak, the variety of human life-styles.

Situated in the South-West of the Indian Ocean, Mauritius is an independent State with 1 million inhabitants, being like Singapore one of the most densely populated island states of this world. Unlike Singapore and Hong-Kong, however, Mauritius is isolated in the Indian Ocean being over 600 km away from Madagascar and over 1000 km away from continental Africa, but having in counterpart over one million sq. km of ocean nominally under its economic control.

Selection of communities

Two small communities were selected, from different parts of the island, for the clarity of their "commonly believed" needs and problems. Each will be referred hitherto by the letter indicated below.

Community A: A major pre-occupation is believed to be with sugarcane cultivation, with land and agriculture generally. The village of Moka, situated close to the centre of the island, close to M.D.A. sugar factory and surrounded by sugarcane fields. The main occupations of people being sugarcane cultivation and production, general agriculture, shopkeeping and other village services; there are also quite a few members of the liberal professions.

Community B: Major pre-occupation is believed to be unemployment and the need to eke out a living.

Cité Attlee is a low-income housing estate in the southern suburbs of Curepipe (the second largest town of the island). The inhabitants are mainly artisans, house employees, drivers, knitting factory workers (women only) together with a fairly large proportion of unemployed (especially among the youth).

Description of the study

Phase I: "Believed" needs and problems of ten communities were arrived at through personal experience and conversation with village development officers, youth leaders, politicians and others. In all cases only the person's opinion as to "what are the main problems of these people" was requested. Thus over-all and externally viewed opinions were obtained. Two communities (A and B) were then selected for the study.

Phase II: Two separate groups of enquirers were constituted.

(i) A group of student-teachers were asked to visit the two areas concerned and establish what according to them were the major needs and problems of the communities visited. They utilised only their own observations, no interviews. None of the visitors belonged to the communities concerned. Their lists represent an EXTERNAL EVALUATION OF NEEDS.

(ii) Teams of 6 people (1 student-teacher, 2 primary school teachers, 3 voluntary social workers) belonging to each of communities A and B were asked to establish lists of needs and problems of their own communities. They interviewed people from different age groups and occupations and utilised their own personal experience to establish lists which represent an INTERNAL EVALUATION OF NEEDS.

Findings

Community A

Either because problems of agriculture are already well known or because sufficiently covered by agricultural extension services these do not present any problem to the community.

The most strongly expressed needs are situated in the domain of health/birth control/child care/schooling together with a concern for learning how to mend things in the home.

(The "generally believed" needs of the community preoccupation are with sugarcane cultivation with land and agriculture generally) are thus entirely false. On the basis of this survey a program of biological education for this community would thus be clearly based on HEALTH with as an immediate priority the popularisation of methods of birth control.

Can it be concluded that this community is no longer an agricultural, rural community but has changed into a "modern" village whose main concern is welfare?

Community B

The actually expressed needs of community B compare fairly closely with the "generally believed" needs, in that unemployment and problems related to employment are in both cases in the forefront. However, a concern for health and disease prevention are found to be important.

Birth control and family planning methods which appeared as priority 1 in community A have low priority in community B; either these methods are already well known here (Action Familiale is known to be active in this Cité) or these do not pre-occupy people unduly.

In an eventual community-development action the major inputs into B would be of a social, economic and political nature. The biological sciences could help the members of Community B in dealing with their concern for health and disease prevention - an understanding of the concept of rational use of resources could also be useful. The biosocial concept of self-sufficiency (produce your own food, learn disease prevention and home management) could perhaps be introduced with some emphasis on unemployment.

iii) Examples of Project and Test Questions

[Following projects and test questions suggested by author.]

. Project. After a class discussion choose one major issue of concern to the community nation-wide. The issue should have something to do with biology or have links with biology (eg the drug problem, energy supply, food resources, family planning, acid rain etc.).

Over the next month the class should build up a newspaper file of articles referring to this matter. At the end of the month review the file and discuss the following questions in class groups.

(a) Look through the articles and roughly sort them into three groups - (i) those mainly giving facts (ii) those mainly making guesses and (iii) those mainly giving opinions.

(b) How did you make a judgement between "facts", "guesses" and "opinions"?

(c) In which ways do newspapers mix together and use facts, guesses and opinions in their articles so as to make the stories more dramatic and so hold the interest of readers?

(d) What areas (topics) in (i) biology and (ii) other areas would you need to study to get more information on this matter?

(e) What solutions to the problem (if any) were proposed in the articles? Which of these seemed to you to be the most useful and effective? Explain.

(f) In what ways could you personally help to reduce the negative effects of this problem on the welfare of the community?

- Project. Let us assume that your general community is becoming more and more concerned about the illegal use of drugs and about drug-related crimes.

  Plan a campaign to educate teenagers and young adults about the dangers and problems of using drugs. Write about the following.

  (a) Objectives of the campaign. What you hope to achieve.

  (b) The information you would like to produce. List this as a set of headings and subheadings.

  (c) Write out in more detail what illegal drugs such as heroin do to the body and the mind. How could you convince young people of the dangerous effects of drugs?

  (d) Explain how the use of illegal drugs and criminal activities are linked.

  (e) Set out in steps your plan of action for the campaign.

  (f) Explain how you could check up whether or not the campaign has been effective.

- Project. Choose a major social problem of concern to most members of the community - choose a matter with some basis in biology or which has links with biology. Discuss the following:

  (a) What might be some of the factors which have caused the problem and which tend to make the problem more acute?

  (b) What are some of the factors in the community which are working to make the problem less difficult for everyone?

  (c) Make some suggestions about how the community could reduce the effects of those factors tending to make the problem worse.

  (d) Make some suggestions about how the community could strengthen those positive aspects of society which would make the problem less acute.

  (e) Looking now at the balance between the factors working to make the problem more acute, and the factors working to reduce the impact of the problem or to solve it altogether recommend what each of the following groups or individuals should do to get rid of the problem.

  (i) national government
  (ii) local government
  (iii) mass media
  (iv) voluntary groups
  (v) schools
  (vi) individuals
  (vii) you personally

. Test Questions

(1) Choose one major social issue of concern to the community as a whole. The concern should have some basis in biology or have links with biology.

Assume you are a qualified biologist. What advice could you give the government to reduce the impact of this social problem on the wellbeing of society as a whole? [Write about 4 pages]

(2) The following issues or situations are of concern to people in many countries of the world.

(i) illegal use of drugs
(ii) air pollution and its effects on health
(iii) low standards of living of some families
(iv) some parents having more children than they can really afford to look after and educate
(v) old fashioned farming practices which destroy the soil and reduce the amount of food available for the people.

Choose any three of the above issues. For each write about one page on how biological knowledge and skills could be applied to reduce its negative impact on society.

(3) How does a scientist go about identifying and solving a problem in biology? Could similar methods be used by social workers, government officials or local community leaders to solve social problems of major concern to the community as a whole? Explain your point of view.

8.8 National Science Policy

i) Rationale

The determination of science policy is an important and complex area which receives surprisingly little attention in courses of school science, and hardly any at all in biology programmes.

There are three areas of science policy which perhaps should receive attention in school biology. The first is policy determining the advance of science itself. In this area there is interaction between three elements. These elements are the autonomous policies and practices of the scientific community itself; the second is the influence brought to bear on the scientific community by government intervention through the provision of funding and by regulation; and the third is the influence of the community at large which expresses concerns and directly exerts pressure on science by influencing the scientific community or indirectly through its impact on government.

In the past the advance of science was largely left to scientists themselves and the scientific community was reasonably autonomous. That is no longer the case. Governments, and the community at large now set limits and order priorities and so the compass of scientific knowledge is determined more and more by forces external to the scientific enterprise.

The second area is the determination by a government of the priorities to be given to various aspects of applied science. How much scientific output should be diverted to supporting defence and the military industrial complex, how much should go to development in areas such as high technology, industrial innovation, agricultural improvement, advances in medicine and health services, the space programme, and so on. The changing emphasis given by government to these various aspects inevitably influences how science as a whole moves forward and also influences community perceptions about the nature and role of science in society.

The third area of science policy which could be addressed by school science is how science and science-related industries and activities are regulated in the national interest and in the interests of the community at large. In this area legal aspects are important, including a review of laws to control aspects such as (i) use of the products and techniques of bioengineering, such as gene splicing (ii) applications of in vitro fertilization techniques, experiments with human embryos, abortion and surrogate motherhood (iii) use of animals in biological experiments (iv) hazard controls in activities involving for example mutant bacteria or radiation (v) environmental protection including pollution controls and (vi) industrial regulations such as limits to prevent overfishing, quality controls in food processing and hygienic and other standards for housing.

It is not suggested that secondary school biology should necessarily make such policy studies central to the curriculum. It is suggested, however, that sufficient examples be reviewed to show (i) that the content of science is not determined by some inherent qualities of science itself but by societal forces; (ii) that science policy is determined by society and, (iii) that in a democracy the determination of science policy should be based on rational decision making at all levels of the community.

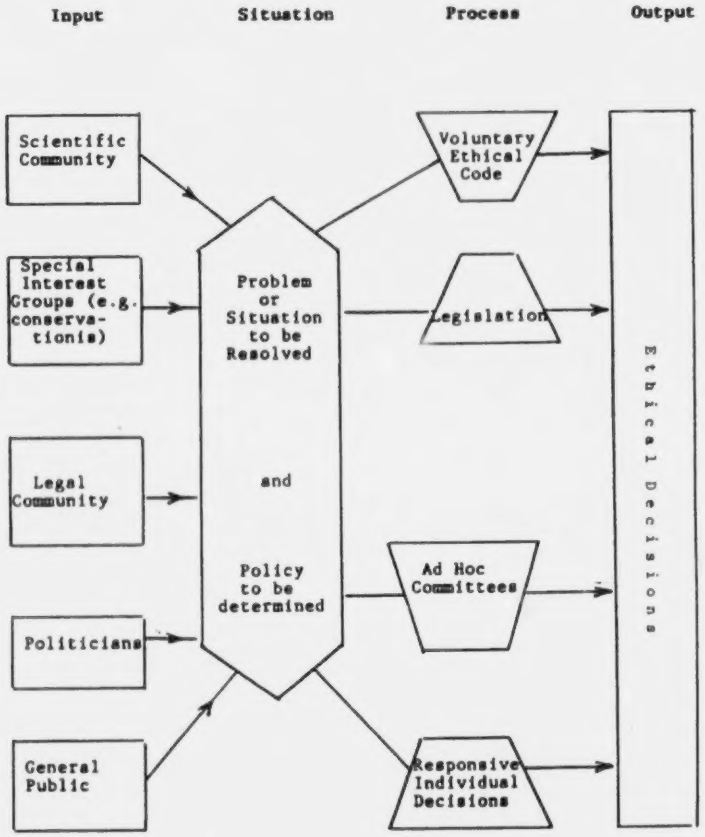
ii) Examples of Content

Example 8.34: Public participation in science policy

School System: -
Approach: *Background reading for teachers. An extract from an article suggesting how national policy in regard to bioethics emerges as the product of social interaction*
Source: *G. Rex Meyer "Current Issues in Bioethics: An Educators Response" Biology International Special Issue 11 (New Challenges for Biological Education edited by Schaefer, G. and Younes, T.) pp 27-29.*

Determining National Policies in Bioethics

Public participation in science policy has become much more prominent and overt since the Conference on rDNA Research held at Asilomar California in 1973 and its subsequent events. While the pattern varies a little from country to country its main elements could be represented in a general way as shown in the figure below.


Input
Situation
Process
Output
Scientific Community
Special Interest Groups (e.g. conservationis)
Legal Community
Politicians
General Public
Problem or Situation to be Resolved
and
Policy to be determined
Voluntary Ethical Code
Legislation
Ad Hoc Committees
Responsive Individual Decisions
Ethical Decisions

Community Participation in Science Policy.

As shown in the figure at least five types of group in the community are involved in decision making leading to formulation of science policy - in this case policy related to bioethics.

a. The Scientific Community: There are still members of the scientific community who need to be convinced of the inevitability of public participation in determining science policy. The arguments for and against public participation need to be presented to scientists and the advantages and disadvantages carefully evaluated. Further, the processes of decision-making should be examined by means of case studies - for example, the history of policy making about rDNA since 1973; the events leading up to recent Swedish legislation on aspects of artificial insemination by donor, and ethical aspects of human genetical research and manipulation of the genome. Much of this education could be gained through formal programmes offered by universities and colleges but should also continue throughout the professional life of a scientist.

b. Special Interest Groups: Strong-minded special interest groups are now very obvious in our communities and, agree with them or not, they have a right not only to be heard, but in a true democracy, to have their views influence bioethical decisions - at least in proportion to their voice and their ability to convince others. I need only cite the anti-nuclear and conservation movements and the right-to-life factions, not to mention various political parties. These groups need to be involved in specifically targeted educational programmes if their voice is to be rational and informed.

c. Legal Community: It goes without saying that in today's complex world many scientific activities and their outcomes have legal implications. The legal profession has, in the past, at least in some countries, suffered very much from the so-called "two-cultures" syndrome. Lawyers have tended to be ignorant of science, and scientists ignorant of the law. Each group needs to be informed not only of major areas of substantive concern to the other but of value systems and processes of decision-making employed by each profession.

d. Politicians: Politicians usually do nothing that may endanger their re-election, but at least those decisions they are able to make should be informed decisions. Continuing education in the area of bioethics and in relation to legislation about science policy for politicians - unfortunately can be only "issue-related". This is due to the shifting sands of politics; to the short-term views of most politicians, and because, like journalists, politicians usually only need to cope with one transitory issue at a time. This means that continuing education in science should provide politicians with detailed briefs on each issue, as it arises. The recent battle in Australia to conserve the Franklin River wilderness area in Tasmania is a clear case of the success of this approach.

e. General Public: Education in bioethics for primary schools and high schools should go a long way towards helping the general public make rational and informed decisions about science policy. Unfortunately, however, schooling alone is not enough and the continuing adult educator in science has a special responsibility to heighten awareness about bioethical issues and to improve skills of decision-making. A key target in this regard are journalists. The mass media not only reflect public opinion but also to a degree determine public opinion. Journalists need to be continually informed of the facts involved in each science policy issue as it arises. Important aims for the continuing science educator in dealing with the general community therefore include (i) explaining the values and methods of the scientific community; (ii) combating irrational views of the world - e.g., pseudosciences such as astrology, ufology, creation-science and so on; and (iii) improving techniques of rational problem-solving and skills of evaluation.

Example 8.35: National policy for environmental education

School System: -
Approach: *Background reading for teachers analyzing how national policy is formulated in the area of environmental education*
Source: *Rugumayo, Edward "Key Issues in Environmental Education" Biological Education Newsletter IUBS-CBE No 9 August 1983 pp 11-20.*

In identifying key issues in environmental education, there are certain necessary steps which have to be gone through before actual definition of the issues is attempted. Fig. 2 shows these necessary steps.

In Third World countries, it has been found that a national programme for environmental education must be launched if the ideas and plans about conservation and environmental education are to have the desired effect. Most developing countries have national science research councils, thanks to the UNESCO which has done so much to encourage the establishment of these bodies. These bodies, in collaboration with the appropriate government ministries and educational institutions, work out the necessary steps in defining the key issues in environmental education in which biology has a significant role to play. This role should be seen as a *complementary* one to the roles played by the *other disciplines* -- engineering, medicine, agriculture, social sciences, etc.

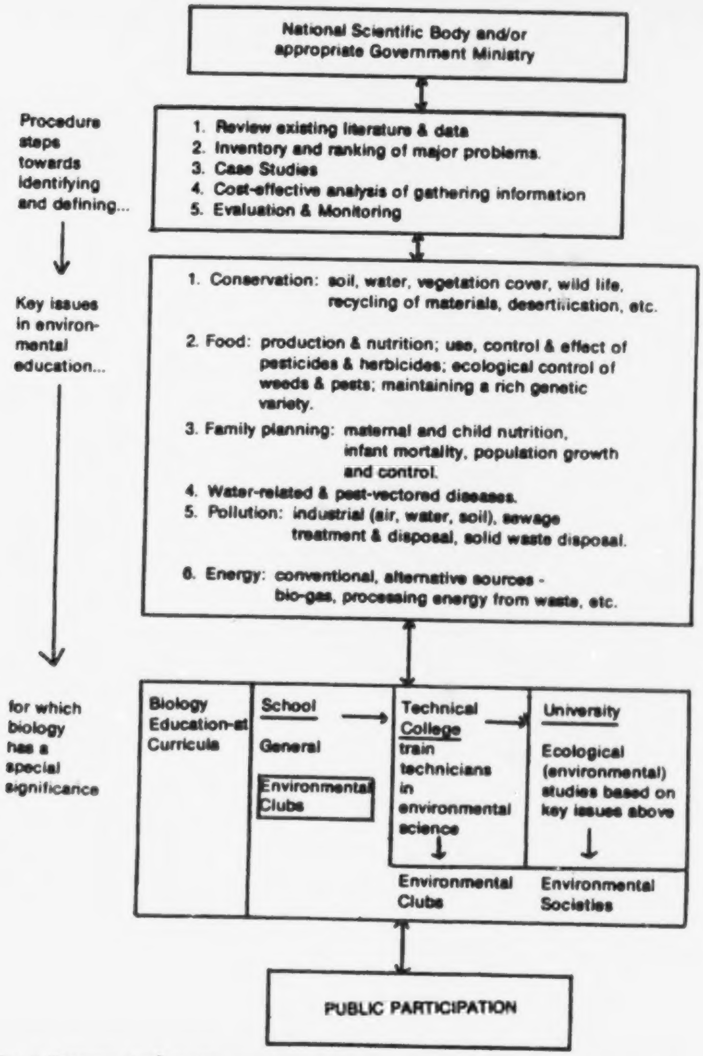

National Scientific Body and/or appropriate Government Ministry
Procedure steps towards identifying and defining...
1. Review existing literature & data
2. Inventory and ranking of major problems.
3. Case Studies
4. Cost-effective analysis of gathering information
5. Evaluation & Monitoring
Key issues in environmental education...
1. Conservation: soil, water, vegetation cover, wild life, recycling of materials, desertification, etc.
2. Food: production & nutrition; use, control & effect of pesticides & herbicides; ecological control of weeds & pests; maintaining a rich genetic variety.
3. Family planning: maternal and child nutrition, infant mortality, population growth and control.
4. Water-related & pest-vectored diseases.
5. Pollution: industrial (air, water, soil), sewage treatment & disposal, solid waste disposal.
6. Energy: conventional, alternative sources - bio-gas, processing energy from waste, etc.
for which biology has a special significance
Biology Education-at Curricula
School
General
Environmental Clubs
Technical College
train technicians in environmental science
Environmental Clubs
University
Ecological (environmental) studies based on key issues above
Environmental Societies
PUBLIC PARTICIPATION

Fig. 2 Diagram showing the procedure necessary in identifying key issues in environmental education and how these may be integrated into a national environmental education programme.

Example 8.36: National policy in regard to health care of infants with birth defects

School System: USA secondary school biology
Approach: Case study of the determination and application of government policy in bioethical considerations in the area of child care
Source: Biological Sciences Curriculum Study: The Case of Baby Jane Doe: Reprint of chapter for new edition of BSCS volume on Human Genetics courtesy of the publishers. Colorado Springs: BSCS 1988

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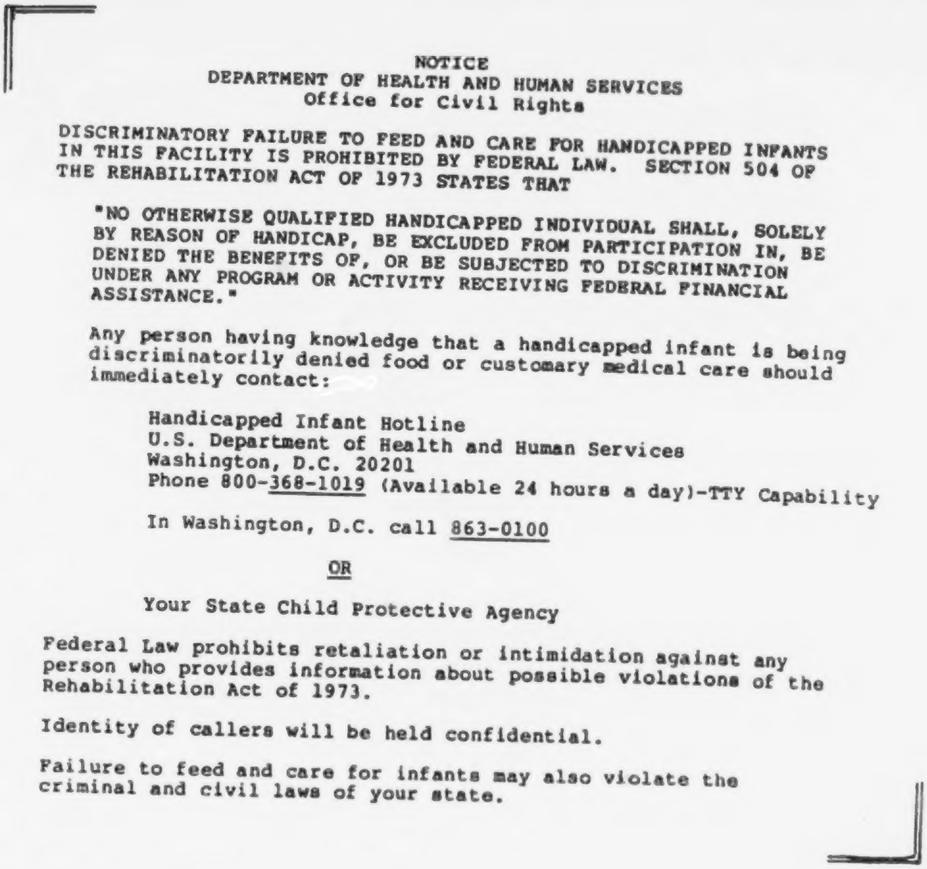

NOTICE
DEPARTMENT OF HEALTH AND HUMAN SERVICES
Office for Civil Rights

DISCRIMINATORY FAILURE TO FEED AND CARE FOR HANDICAPPED INFANTS IN THIS FACILITY IS PROHIBITED BY FEDERAL LAW. SECTION 504 OF THE REHABILITATION ACT OF 1973 STATES THAT

> "NO OTHERWISE QUALIFIED HANDICAPPED INDIVIDUAL SHALL, SOLELY BY REASON OF HANDICAP, BE EXCLUDED FROM PARTICIPATION IN, BE DENIED THE BENEFITS OF, OR BE SUBJECTED TO DISCRIMINATION UNDER ANY PROGRAM OR ACTIVITY RECEIVING FEDERAL FINANCIAL ASSISTANCE."

Any person having knowledge that a handicapped infant is being discriminatorily denied food or customary medical care should immediately contact:

Handicapped Infant Hotline
U.S. Department of Health and Human Services
Washington, D.C. 20201
Phone 800-368-1019 (Available 24 hours a day)-TTY Capability

In Washington, D.C. call 863-0100

OR

Your State Child Protective Agency

Federal Law prohibits retaliation or intimidation against any person who provides information about possible violations of the Rehabilitation Act of 1973.

Identity of callers will be held confidential.

Failure to feed and care for infants may also violate the criminal and civil laws of your state.

The Case of Baby Jane Doe

On 15 April 1982, a six-day old boy, known as John Doe, died in Bloomington Hospital in Indiana. The child was born with a digestive system disorder, tracheo-esophogeal fistula, that is generally correctable through routine surgery. However, the child also had Down syndrome. The child's parents refused the corrective surgery and denied food and water, all with the approval of the courts.

On 18 May 1982 the United States Department of Health and Human Services (DHHS) published a "notice to health care providers". The notice said in part:

> There has recently been heightened public concern about the adequacy of medical treatment of newborn infants with birth defects. Reports suggest that operable defects have sometimes not been treated, and instead infants have been allowed to die, because of the existence of a concurrent handicap, such as Down's syndrome.

> This notice is intended to remind affected parties of the applicability of section 504 of the Rehabilitation Act of 1973...Under section 504 it is unlawful for a recipient of Federal financial assistance to withhold from a handicapped infant nutritional sustenance or medical or surgical treatment required to correct a life-threatening condition, if: 1) the withholding is based on the fact that the infant is handicapped; and 2) the handicap does not render the treatment or nutritional sustenance medically contraindicated.
>
> For example, a recipient may not lawfully decline to treat an operable life-threatening condition in an infant, or refrain from feeding the infant, simply because the infant is believed to be mentally retarded.

Ten months later, DHHS published more forceful, follow-up regulations. Those regulations required that a notice be posted in pediatric units, newborn nurseries, and neonatal intensive care units detailing the obligations of health-care providers to handicapped infants. The poster also included a toll-free hot line number so that individuals could report anonymously to the government violations of the regulations. Those suspected violations would result in a visit to the facility by investigators from DHHS.

From 17 March to 14 April 1983 approximately 600 calls were made on the hot line. Most were for information. Only 16 made specific allegations of abuse, and only five merited the attention of investigators.

The American Academy of Pediatrics and other health-related organizations sued DHHS on the grounds that the regulations had been promulgated without the required 30-day comment period after publication in the Federal Register. The regulation was ultimately overturned in court on that basis. The judge also criticized the underlying intent of the regulations and strongly indicated that they were ill conceived. The Justice Department then began drafting new regulations, the last of which was published on 12 January 1984. The new regulations differ little from the 1982 regulations. The notice (now smaller) must now be visible only to doctors and nurses. DHHS also suggests that hospitals establish "infant care review committees".

Baby Jane Doe was born 11 October 1983 at St. Charles Hospital in Port Jefferson, New York. She had spina bifida and was microcephalic and hydrocephalic. Doctors informed her parents that unless she underwent corrective surgery she could be expected to live no more than two weeks to two years. Even with the surgery, however, although she might live 20 years, she would "be severely retarded, epileptic, paralyzed, bedridden, and subject to constant urinary tract and bladder infections". She was transferred to the State University Hospital at Stony Brook, New York in anticipation of the surgery. However, after discussions with neurologists, religious consultants, nurses, and a social worker, the parents decided against the surgery.

Lawrence Washburn, a Vermont attorney active in right-to-life affairs, received anonymous notification that Baby Jane Doe was being denied life-saving treatment. Mr. Washburn sued to require the surgery, and his suit was upheld in a lower court in New York. One day later, the Appellate Division of the State of New York reversed the decision, and the New York Court of Appeals, the highest court in New York, upheld the reversal one week later, entirely on procedural grounds.

Shortly after the decision by the New York Court of Appeals, the United States Justice Department sued Stony Brook Hospital "claiming that [the government] had the right to see [Baby Jane Doe's] hospital records, to ensure there was no violation of section 504 of the Rehabilitation Act". The attorneys for the hospital and the parents argued that this was "a dangerous precedent to allow the federal government access to confidential medical records, as well as an intolerable invasion of the parents' privacy". Federal District Court Judge Leonard D. Wexler disallowed the government's request on 17 November 1983. On 20 January 1984 a second U.S. district court judge (Roger Miner) disallowed a suit by Mr. Washburn requesting that the court appoint a guardian ad litem to protect Baby Jane Doe's interests. Mr. Washburn was also fined $500 for "filing an incorrect or improper action".

In the case of Baby Jane Doe, what are the goals, rights, and duties of: a) the parents; b) the attending physicians; c) the federal government; d) society at large; and e) Baby Jane Doe herself?

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* Compiled from articles in The Hastings Center Report, Vol 12, No 4; Vol 13, No 3; and Vol 14, No 1, and from Singer, P. and Kushe, H. "The Future of Baby Doe" New York Review of Books Vol 31 No 3 1984 p 17.

Example 8.37: Application of government policy

School System: Australia. Victoria secondary school biology
Approach: A case study to show how biological concepts can be involved in the formulation and application of government policy in the area of human organ and tissue transplantation
Source: Brumby, Margaret "Teaching and Learning About Issues in Biology" Unesco: New Trends in Biology Teaching Volume V. Paris: Unesco 1987 pp 45-57.

Case study a legal definition of death

In 1982 the State Parliament of Victoria (along with other States in Australia) enacted legislation to regulate the donation and transplantation of human tissue. Among its clauses this Act sets out the requirements to obtain consent, limits the use of regenerative and non-regenerative tissue, and of donations from children, and prohibits the commercialization of any human tissue including blood. However, probably the most significant clause in the Act sets out the criteria relating to the time when essential organs may be removed from a body, for this required a legal definition of death.

This is what the Human Tissue Act (Vic, 1982) states:

> 'Part IX. - Definition of Death
>
> S.41 For the purposes of the law of Victoria, a person has died when there has occurred --
> (a) irreversible cessation of circulation of blood in the body of the person; or
> (b) irreversible cessation of all function of the brain of the person.'

The boundary between science and the law

Before this Act, evidence (both in a medical and legal sense) that death had occurred was that a person's heart and breathing had both permanently stopped. Section 41(b) (often referred to as the 'brain-death' clause) is a new criterion for deciding whether a person has died. The phrase 'all function' suggests activity of the brain stem (where body temperature, blood pressure and breathing are controlled) as well as the brain cerebral cortex (where consciousness, memory, thinking, feelings and responses to the environment are carried out) must both have stopped. A person in a deep coma, as a result of permanent damage to the cortex, is, under this definition, still clearly alive.

The law has used biological concepts in its legal definition. From a scientific perspective, however, this definition does not cover two points:

- *How the two signs are to be observed.* Section 41(a) implies the presence or absence of a beating heart, perhaps as shown by an electrocardiogram (ECG). Section 41(b) may be detected by the presence or absence of any electrical activity in the brain, as shown by an electroencephalogram (EEG).
- *Whether the two signs (blood circulation and brain function) must be occurring naturally, unaided by machines.* Artifical life-support machines can maintain both blood circulation and breathing. Such technology therefore already creates problems. If a person is not able to carry out these two functions unaided, is he or she already dead, i.e. are the machines attached to a corpse? If the person is still considered 'alive' while on the machines, then does switching off the machines constitute killing the person?

Legal answers to problems created by new bio-medical technology may not be completely adequate.

iii) Examples of Project and Test Questions

The following examples are suggestions by the author. Sources of materials on which the questions are based are indicated.

. Project. Types of Government Science Policy (for Senior Students)
The US science commentator Dean Schooler has suggested that there are several categories of policy making in science and these can be grouped into three levels according to the degree of influence and control exercised by government. These categories are listed and summarised below. (Source: Schooler, Dean Jr. Science, Scientists and Public Policy. New York: The Free Press 1971.

A. Policies where government has limited influence

(i) Self regulation by private group or industry eg. packaging.
(ii) Social regulations to protect underprivileged in terms of their rights, financial assistance etc. eg. social security legislation.
(iii) Government policy to reorganize its own roles, functions and powers eg. reorganization of a ministry.
(iv) Regulations aimed at international relations eg. foreign aid, arms control.
(v) Government distribution of benefits to defined groups who do not compete with each other eg. agricultural subsidies, subsidies to certain areas of transportation.

B. Policies where government moderate influence

(vi) Government distribution of benefits to groups who are in competition eg. conservation groups, anti-pollution programmes, safety in transportation.

C. Policies where government has a high influence

(vii) Government regulation of aspects of the economy in the general interest eg. taxation, balancing benefits to different industries.
(viii) Community wide standards and security areas eg. national health policies, weather, defence
(ix) Government itself as an entrepreneur in manufacture, production or distribution eg. space programme, research and development in science.

Discuss this list in your class to make sure you understand the characteristics of each type of policy. Then form into discussion groups and review the following questions.

(a) Choose one policy area from each of groups A, B and C and describe a specific example of a policy or set of regulations in that area. You may need to do some library research. (Choose areas with a strong science component or with links to science.)

(b) To what extent do you consider biological science has influenced the formulation of the policy or regulations you have selected?

(c) The policies listed have been grouped into those with limited, moderate and high government influence. For the three examples you have chosen discuss why they have been classified in that way. Do you think the classification is appropriate? What do you think should be the balance between self regulation and government regulation in the policy areas you have selected?

(d) To what extent should scientists determine official policy in areas with an obvious scientific component (eg.

regulation of organ transplants, experiments with human embryos, control of pollution)? Should scientists have the final say?

. Project. Government regulation of fishing industry

Study the following summary of government regulations for the fishing industry.

(Source: University of the Philippines Science Education Center (UPSEC): Fish Conservation and Preservation Part 2 Pollution and Conservation. Manila: UPSEC/UNICEF 1978 pp 8-11.)

Fishing Regulations

The problem of overfishing in the Philippines has caused the proclamation of Presidential Decree No. 704 that deals with fishing and fisheries.

This decree prohibits some activities so that fish can be conserved, these are:

1. It is not allowed to catch or sell fish and other water life caught by using

   (a) explosives such as dynamite or other chemical compounds that explode.
   Dynamite not only destroys matured fish but also eggs, larvae and fingerlings. Fishes that live after the dynamiting are likely to leave the place where they live and never come back. With continuous use of explosives, there will be less fish in the area.

   (b) poisonous substances such as plants, extracts or juices of plants and chemicals harmful or harmless to human beings.
   Some fishes may not be killed by the poison, but the poison may collect instead in their tissues. If eaten by other fishes, the latter may die. Moreover, persons who eat the fish with poisoned tissues may get sick or die. The poison also kills fingerlings and larvae. The poison going into the bottom of waters may kill water life other than fish.

   (c) electrofishing which uses electricity produced by dry-cell batteries, electric generators or other sources of electric power.
   Electrofishing also kill or make unconscious fish and other water life in fresh or salt waters. If the electric shock is strong, all water life in the area will be killed.

2. Fishing with fine-meshed nets is discouraged.
   Small fish, larvae and fingerlings should not be caught but allowed to mature. Fine-meshed nets may be

used only to gather fry or young fish for placing in ponds, or for catching small but already matured fishes such as glass eels and elvers, tabois or dulong (Ilocos), and alamang.

3. Trawl fishing is not allowed in waters about 13m deep or less.

   If used in waters that are not deep, trawl fishing destroys breeding places and food needed by fish living at the water bottom.

4. Exporting bangus fry is not allowed.

   Exporting fry decreases the domestic supply of bangus at present still below the quantity needed in the Philippines.

5. It is not allowed to pollute or dirty Philippine waters with materials of any kind harmful to fish or other water life.

6. Fishes can not be caught during "closed season". At certain periods fishing is not allowed in certain areas of Philippine waters to protect spawning or growth of eggs or fry of a certain kind of fish or water products. For example: Pigek spawns only once a year in the Rio Grande de Mindanao. When the pigek hatches its eggs, it leaves for the sea. If the pigek is caught at this period, it will soon disappear.

7. No fish corral is to be constructed within 200 metres of another fish corral in seawater fisheries, or 100 metres in freshwater fisheries.

   If fish corrals are too close, fishing boats cannot move freely among them. Too close corrals also disturbs the flow of current carrying dissolved oxygen and food to the enclosed fish.

In your class discuss the regulations to ensure you understand all the main points. Then form into discussion groups to discuss the following questions.

(a) What is meant by the term "overfishing"? Explain why the Government of the Philippines issued such detailed regulations for the fishing industry.

(b) What would be the effect of using dynamite or poisons to catch fish from rivers and lagoons?

(c) No mention is made in the regulations of the use of drift nets in deep sea fishing. Why do you think this type of fishing was not covered by the regulations?

(d) In formulating these regulations what advice do you think the government would have obtained from
    (i) people involved in the fishing industry
    (ii) biologists
    (iii) consumers
    (iv) economists
    (v) development planners?

If the government received contradictory advice from various groups how do you think it reached its final decision?

(e) What would the government have to do to ensure that these regulations were followed by all those involved in the fishing industry?

(f) Do you think that such detailed regulations are (i) fair and (ii) justified? Explain your point of view.

. Test Questions

(Suggestions by the author)

1. A government is considering a policy on whether scientific experiments with human embryos should be permitted. They seek advice from biologists, anti-abortionists, religious leaders and members of the general public.
What advice might be given by biologists? Do you think it is the biologists who should have the final say? Discuss your point of view.
(Write about five pages)

2. Choose a biologically-based primary or secondary industry eg. canning fish; wheat growing; manufacture of pharmaceutical drugs or any other of your choice. What aspects of the industry should be regulated by government? Explain your point of view.
(Write three pages)

3. Assume you were chairing a government committee to determine a national policy for the reduction of air pollution in cities.
   (a) Which community groups would you consult?
   (b) What kind of information would you need to obtain?
   (c) How much reliance would you place on information received from (i) scientists (ii) city residents (iii) journalists (iv) politicians?

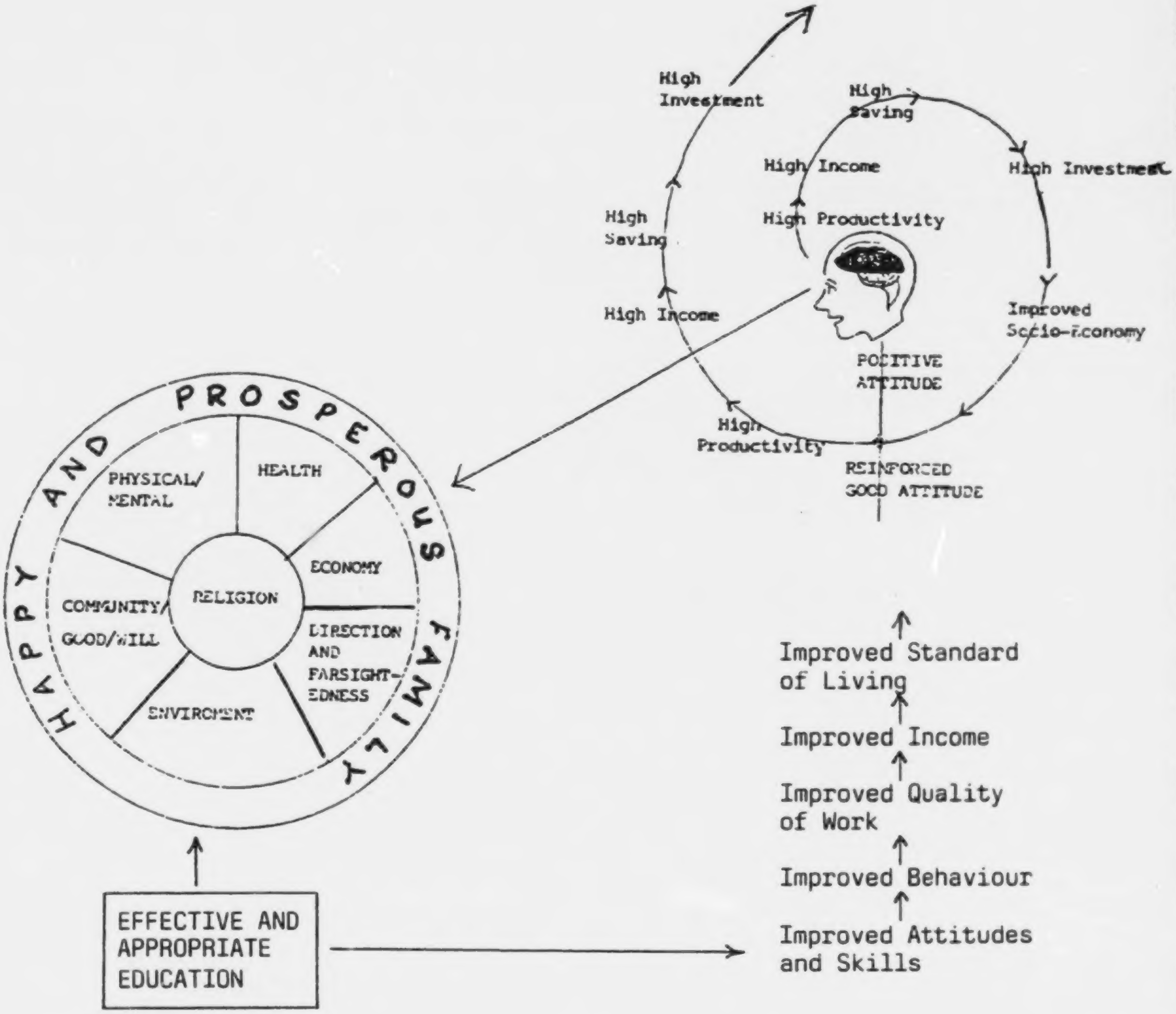
(Write about two pages on each question)

8.9 **Biology Teaching and National Development**

i) Rationale

There is no doubt that there is a strong link between effective and appropriate education and positive national development. An absence of an effective educational system results in a population with poor attitudes and low levels of skill. This in turn leads to low productivity, low income, low savings, low investment and finally to poverty, which further depresses attitudes and further lowers the level of skills - a vicious cycle is set in motion.

In the presence of a strong, effective and appropriate educational system attitudes and skills are improved, behaviour improves, the quality of work is enhanced, incomes are increased, an improved standard of living ensures and this further enhances attitudes and skills. A spiral of positive growth follows with the positive attitudes and enhanced skills leading to still further increased productivity, even higher income, higher levels of savings, higher levels of investment and an improved socio-economic climate. This in its turn creates still further positive attitudes and skills which drive a further turn of the spiral through productivity, income, savings, investments, and further socio-economic growth and so the spiral of development goes on. This idea is illustrated in the figure below (17).


High Investment
High Saving
High Income
High Investment
High Saving
High Productivity
Improved Socio-Economy
High Income
POSITIVE ATTITUDE
High Productivity
REINFORCED GOOD ATTITUDE
HAPPY AND PROSPEROUS FAMILY
PHYSICAL/MENTAL
HEALTH
ECONOMY
RELIGION
COMMUNITY/GOOD/WILL
DIRECTION AND FARSIGHTEDNESS
ENVIRONMENT
Improved Standard of Living
Improved Income
Improved Quality of Work
Improved Behaviour
Improved Attitudes and Skills
EFFECTIVE AND APPROPRIATE EDUCATION

The relationship between education and development.
(Based on Unesco: Continuing Education New Policies and Directions: Draft Edition. Bangkok: Unesco Proap 1990)

Improved socio-economic climate leads to the emergence of a happy and prosperous community based on a sound economy, responsible environmental policies, good standards of mental and physical health, a sound spiritual philosophy and a sense of farsightedness.

Central to this model of development is the concept of human resource development (HRD). According to UNDP human resource development is the process of enlarging people's choices. People should lead long and healthy lives, be well educated and have access to those resources needed for a decent standard of living. UNDP has now created a new "development index" - an Index of Human Development (the HDI) to go together with the well known socio-economic growth index - the index of Gross National Product (GNP). Countries can now be classified as having low, medium or high HDI. The indicators of HDI include life expectancy, adult literacy levels and purchasing power. This new index focuses on how human wellbeing translates into economic growth and vice versa (18).

As we have suggested, however, human wellbeing depends on effective and appropriate education. Appropriate education includes science education and in particular, a well structured and well presented socially oriented biology programme. According to Dr. Digby Swift, a senior education adviser with the UK Overseas Development Administration, "there is ample evidence of the benefits of science and technology. There are demonstrable advantages of having people who have at least some scientific and technical literacy (see section 8.2).

> ...Science does to some extent make people more aware of their surroundings. Many employers value scientific qualifications even for posts not directly requiring scientific competence. There is evidence that development prospers among people with a sufficient background in science to understand the reasoning behind new methods of agriculture or hygiene. There is also ample evidence of problems that have arisen, some on a grand scale, as a direct result of scientific or technological ignorance by politicians and others." (19)

What is required, however, is not just biology education in a vacuum but biology education in a social context. If school biology is to contribute strongly to human resource development then the ideas outlined in this discussion should be dealt with in the biology curriculum. Links between a knowledge and understanding of biology and the idea of national development based on both human resource development and economic growth should be made clear. As in other areas where science and society interact transfer is not likely to occur unless the links are made overt.

ii) Examples of Content

Example 8.38: A model for national development

School System: India. secondary schools.
Approach: Background reading for teachers on a model for national development emphasising the central role of health and nutrition
Source: Devadas, R.P. "A Major Factor in National Development: Nutrition" in Lewis, J.L. and Kelly, P.J. Science and Technology Education and Future Human Needs. Oxford: Pergamon Press for the ICSU Press 1987 pp 99-106.

Meaning of National Development

Development means development of human beings, all human beings. It means development of their whole being and that of their family and community. The aim of national development is to improve the conditions of life for the entire population in a country and to ensure for the population freedom from hunger and want. It also implies providing reasonable opportunities for effective participation in the productive endeavours which will enhance and enrich the quality of living of the nation.

Development has been often viewed as synonymous to economic growth. It has now become clear that increases in the Gross National Product (GNP) and the per capita income do not necessarily lead to reduction in poverty and malnutrition among the lower socio-economic groups of the population. Equitable distribution of income and social justice must result in the percolation of the benefits of economic development to the poorer sections.

Development means more of the good things of life for all strata of society whether a hard working labourer in the farm or the factory or the professional elite. Development means the ability to attain one's goal in personal and national life. It means fulfilment of individual needs and maximisation of human happiness.[1]

Development is the goal of national planning. It is measured by the extent to which the skewed distribution of wealth is corrected by the number of people who are lifted above the poverty line, the facilities provided to them for education, health and housing, the range of employment generation, economic growth, price stability, political participation of the unorganised and disinherited majority, and cultural progress. Overriding the economic indicators, are the indicators born out of the "Basic Needs Approach". The basics needs are: food and nutrition, drinking water, health, shelter, clothing and education. These are the real indicators of personal, family and national development.

Components of National Development

The various components of national development are interrelated as shown in the flow diagram in Fig. 1.

When one factor is affected the other factors are automatically affected. Hence for the total development of the nation, all the requirements need to be fulfilled. Development must therefore be conceived as a holistic, organic and dynamic process. The planning for such development requires a human centred approach. Its implementation calls for a pragmatic education through the medium of human and spiritual values.

Among the various factors influencing national development the role of nutrition is crucial. It conditions the socio-economic, scientific and cultural aspects of society by influencing the health and vigour of the individual and the community and by prevention, treatment and recovery from disease.

Health is essential for achieving human development, and the development of the nation as a whole.[2] Improvement of the nutritional status of the population can be achieved only through the combined and concerted efforts of all the interrelated professions, and physical and social scientists and educators. As Swaminathan[3] points out, the nutritional goal in India should aim at both producing more and better quality foods and at generating additional purchasing power among the rural and urban poor. Along with these efforts, nutritionists need to work hard to improve the nutritional attitudes of the society.

Article 47 of the Indian constitution indicates that the raising of the levels of nutrition and standards of living are primary duties of the state. The raising of the levels of living, that is improvements in the quality of life, must take place at the health level, and education level. While the well being of men and women depends heavily on economic, education, environmental and other opportunities, nutrition remains the centre piece of development. Singer[4] regards better nutrition as the whole purpose of development.

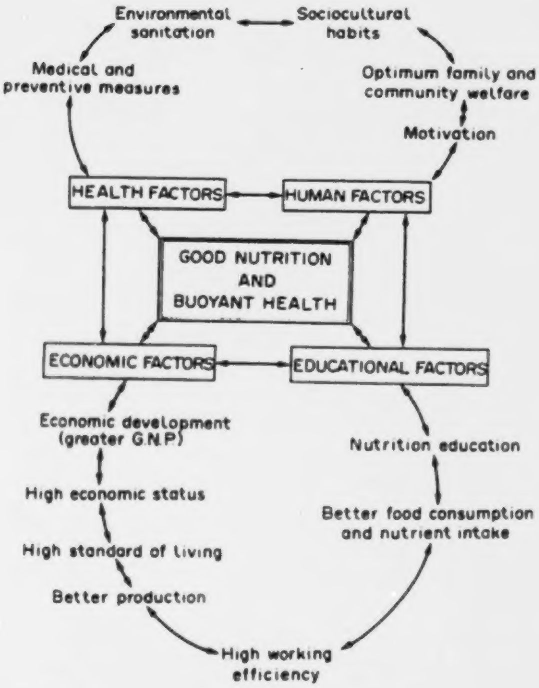

Environmental sanitation
Sociocultural habits
Medical and preventive measures
Optimum family and community welfare
Motivation
HEALTH FACTORS
HUMAN FACTORS
GOOD NUTRITION AND BUOYANT HEALTH
ECONOMIC FACTORS
EDUCATIONAL FACTORS
Economic development (greater G.N.P.)
High economic status
High standard of living
Better production
Nutrition education
Better food consumption and nutrient intake
High working efficiency

FIG. 1. Components of National Development.

References

1. W. E. Weidner. *Goals Strategy and Environment of Development: Dynamics of Development—An International Perspective*, Concept Publishing Co, pp. 31–33 (1978).
2. F. J. Stare and M. McWilliams. *Living Nutrition*, John Wiley and Sons, New York, pp. 1–3 (1977).
3. M. S. Swaminathan. New agricultural technology and employment generation, *Proc. Nutr. Soc. Ind.* No. 23, p. 33 (1978).
4. H. W. Singer. *The Strategy of International Development*, Macmillan Company Ltd, New York, p. 14 (1966).

Example 8.39: Priorities in planning for human resource development

School System: -
Approach: Essay aimed at planners, curriculum workers and teachers to alert them to the needs of the less privileged in society
Source: Chambers, R. "To Put the Last First" in Lewis, J.L. and Kelly, P.J. Science and Technology Education and Future Human Needs. Oxford: Pergamon Press for the ICSU Press 1987 pp 115-121.

Whose needs?

How we *should* think about future human needs depends on whose needs we are considering. Those most in need are precisely not those who are "first"—the urban—industrial, educated and elites. A majority of the neediest are those who are "last"—rural agricultural—little educated, and concentrated in the poorer countries.

Their numbers are increasing. Rural populations in Africa and Asia have risen fast and will continue to do so, and the numbers in Latin America are large. For every two people in rural Sub-Saharan Africa today three are expected by the end of the century.[1] India's rural population will rise over the same period by roughly the size of its current urban population. Urban poverty is appalling but is more visible. It is in the rural areas of the developing countries of the South that most of the neediest in the world are to be found and will continue to be found. The logic of degree of deprivation and of numbers argues for putting first the needs of those who are "last", the poorer among the rural majority of the South.

This requires an assessment of their needs and priorities. The best experts on what they need are the poor rural people themselves. The needs they express vary by individual, gender, household, village and region, and frequently differ from those supposed by elite outsiders. Very often, though, they include health, livelihoods with secure and adequate food supplies and cash incomes, reserves to deal with emergencies, goods they can buy, shelter, and basic services for health, water, education and transport. For those who are most deprived, livelihoods and health are often the most critical.

First and Last

If these are their needs, how can science and technology education help them to meet them? It is here that the biased system of power and knowledge points professionals in the wrong direction. Again and again, the things valued in science, technology, and education are the opposite of what matter to the rural poor. This shows in a list of contrasts between the preferences of professionals—which usually come first, and the needs and resources of the rural poor—which usually come last.

Professional Preferences[2]

First	Last
Urban	Rural
Industrial	Agricultural
High cost	Low cost
Capital-using	Labour-using
Mechanical	Animal or human

For Technology, Research and Curricula	Inorganic	Organic
	Large	Small
	Modern	Traditional
	Exotic	Indigenous
	Marketed	Subsistence
	Quantified	Unquantified
	Geometrical	Irregular
	Visible and seen	Invisible or unseen
	Tidy	Untidy
	Predictable	Unpredictable
	Hard	Soft
	Clean	Dirty
	Odourless	Smelly
For contact and clients	High status	Low status
	Rich	Poor
	Influential	Powerless
	Educated	Illiterate
	Male	Female
	Adult	Child
	Light-skinned	Dark-skinned
For place	Urban	Rural
	Indoors	Outdoors
	Office, laboratory, clinic, research station	Village, village home, farmer's field
	Accessible	Remote
For time	Day	Night
	Dry and cool seasons	Wet and hot seasons

First Biases Against the Last

Curricula, textbooks, training and research usually emphasise the first list against the last.[3] In agricultural science, tractors are preferred to oxen or hand cultivation, chemical fertilisers to organic, exotic cattle to local goats. Agricultural research concentrates on the cash crops of plantations and mainly of the richer farmers—rubber, sisal, coffee, tea, cocoa, jute, cotton—to the relative neglect of the food crops of the poor—sorghum, the millets, sweet potatoes, cassava (tapioca, manioc, yucca). Medical establishments devote resources to the effects of overeating by the rich—heart disease and obesity, rather than to the effects of malnutrition among the poor. They value transplants and open-heart surgery for a few privileged adults more than tackling the diarrhoeas which kill millions of poor children each year.[4]

Engineers prefer large expensive structures—the huge dam, the two or three-lane highway, the skyscraper—to small and cheap works—local irrigation, improved dirt roads, rural housing. The biases are sustained and strengthened not only by education and training, but also by convenience, commercial interests, research funding, and professional rewards and recognition. All of these draw professionals away from the rural poor and towards the urban rich.

The biases also show in professional status. Nuclear physics has higher prestige than agriculture, surgery than community health, major irrigation with big dams than minor irrigation with small ones. The science Nobel prizes go for "first" research. There has been no Nobel prize for work on cassava or goats.

The biases also generate technology that does not fit the resources and needs of the poor. Crops and practices evolved in favourable conditions on agricultural research stations fit the conditions of the richer farmers, but not those of the poorer. The endless cries for the "transfer of technology" to the poor, and the complaints that the poor are ignorant and stupid when they do not adopt it, overlook the frequency with which the technology is inappropriate. The ignorant and stupid are often not the poor but the scientists blind to the fact that their technology does not fit.

References

1. *See Accelerated Development in Sub-Saharan Africa: An Agenda for Action*. World Bank, 1818 H Street, N.W., Washington, DC 20433, 1981, p. 113.
2. This list is modified from Robert Chambers, *Rural Development: Putting the Last First*, Longmans, UK, 1983, p. 173, which also presents the argument of this paper in more detail.
3. It can be illuminating and startling to take a lecture, curriculum, textbook or course and analyse its content against the first–last lists.
4. In the developing world an estimated 500 million children suffer diarrhoeal infection three or four times each year (James Grant, *The State of the World's Children 1984*, UNICEF, New York, 1984, p. 18).

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iii) Examples of Project and Test Questions

(Suggestions by the author)

- Project. Development Plans. Many countries plan the pattern of their future development for a specific number of years ahead. Frequently these plans are published in government reports and most often they take the form of *Five Year Plans*. The plans cover the major sectors of the economy such as agriculture, industrial development, health, education and so on. The reports specify the objectives to be achieved and these are often spelt out in the form of targets or goals to be achieved by specified dates. The methods of achieving the targets are usually described and a budget is usually proposed. If aid is to be sought from international donors or loans obtained from aid agencies such as the World Bank this is usually stated.

  Go to the library or to the appropriate government planning authority and locate your government's current Five Year Plan or some other report it has issued about the future development of the country. Study the plan and summarize the main types of programmes proposed. Make sure all members of the class understand the main features of the plan.

  Form class discussion groups to consider the following questions.

  (a) What does the report state to be the most urgent development priorities of the country?

  (b) How much finance for the proposed developments is to come from the internal resources of the country and how much from foreign loans or donations?

  (c) Are there any aspects of the overall development plan which assume some input from or liaison with science or science-based activities? If so which of these have something to do with biology?

  (d) Which aspects of the plan depend on making the education system more effective? Would improvements in the quantity and quality of biology teaching help in any way? Explain.

- Project. Sustainable Development. Sustainable development is a concept which focuses on qualitative aspects of planning. For development to be sustainable it should leave the resources of the planet and the quality of the environment for the next generations (your children and your children's children) at a level equivalent to that enjoyed by our generation - and hopefully at a level even better than that. This means that planners must carefully balance the economic needs of development against the needs of the environment and against the need to ensure a steadily improved quality of life for all.

Form discussion groups to review the following questions:

(a) Choose a developmental sector such as agriculture, health, secondary industry, communications or education which has a strong biological component or links with biology. With the help of library research describe the growth and development of that sector in your country over the past ten years. In writing your report choose a series of growth and development indicators such as measures of production, numbers of individuals and institutions involved, earning capacity and so on.

(b) To what extent do you consider that the growth described in (a) has taken into consideration the principles of sustainable development?

(c) Choose two debating teams to debate for and against the topic
"Our national development planning adequately considers the need for sustainable development".

(d) What advice would you give those government planners responsible for the next five year development plan in the sector of your choice to ensure that the principles of sustainable development are upheld?

. Test Questions

1. Answer the following questions writing about ten lines on each.
   (a) What do you understand by the term "Index of Human Development" (HDI)?
   (b) What could be appropriate indicators for HDI?
   (c) List some ways in which biological sciences could contribute to a high Index of Human Development.

2. The development plans of a country should be based on democratic decisions made by many agencies and individuals. If the biological sciences are to contribute to sustainable national development, which groups and which types of people should be called on to advise the government on its developmental plans? Justify your choice.
(Write about four pages)

3. Can national development plans be based only on a scientific analysis of needs or should other factors be taken into consideration? Discuss your point of view.
(Write about five pages)

4. In what ways can the biological sciences contribute to both the economic and the human resource development of a nation?
(Write about five pages)

5. Assume you have read a specific five year plan for the economic development of a particular developing country with a low standard of living. You notice the following policies:
   - (i) Tropical rainforests to be removed and replaced by commercial grain crops.
   - (ii) Small farm holdings worked by many people to be joined together and mechanized so as to employ fewer people.
   - (iii) Small scale manufacturing by individuals in rural villages of goods made from local plant or animal materials - eg. baskets, mats, rugs, furniture - to be discouraged and large city factories established instead.

   (a) List some arguments for and against each of the above policies.
   (Write about one page on each)

   (b) Do you think that such policies would be in the long term interests of the majority of the people and of the country as a whole? Justify your answer.
   (Write one page)

8.10 Societal Tolerance of Ambiguity

i) Rationale

In Chapter Six (Section 6.6) the broadening of the scope of biology teaching to include psychological and sociological aspects of personal development was advocated. This present section extends that concept further. The argument is advanced that the wellbeing of an entire society is determined by the level of psychological development of its average citizens. An important stage in development is the emergence of a truly autonomous personality (20).

An autonomous personality is characterized in part by a clearly defined self image, integration of physiological and psychological factors, a clear conception of role, a sense of self-fulfilment and the vivid expression of feelings. At the autonomous stage of psychological development individuals progress beyond learning styles involving mere conception of complexity and the ability to distinguish between processes and outcomes to a willingness to address much more complex patterns, to be more objective and less biased in their views of the world, to have a broad general knowledge and, in particular, to be willing to tolerate ambiguity.

A society with most citizens at the autonomous stage of personality would indeed be an advanced society. Most citizens would engage in voluntary life-long learning: decisions would be made on the basis of rational problem solving and critical reasoning; all citizens would be well informed across a broad range of issues; there would be tolerance towards minority views and life styles and there would be a willingness to contribute to improving the quality of life for all.

Unfortunately for various reasons, including unequal access to education and other opportunities, to misdirected educational efforts and to economic and other critical inequalities and tensions which inhibit the processes of development, many adults remain immature and fail to become truly autonomous personalities. This presents a major challenge for schooling. All teachers in all subjects at all levels of the educational system should focus on developing the "whole person" with the aim of upgrading the maturity levels of all citizens.

School biology has an especially important role to play in this process. Throughout Chapters 6, 7 and 8 many examples have been given of how biology can promote problem solving skills, critical reasoning, objectivity, values analysis and values clarification and the ability to analyze social situations. Biology programmes can also contribute to the general knowledge component of the autonomous personality.

In particular, however, and this is the main point of this section, school biology can and should help people face up to and cope with ambiguity in their own lives, in the lives of others and in society as a whole. The ability to successfully cope with ambiguity is an essential aspect of the mature autonomous personality and the failure to cope with ambiguity is, conversely, an indication that society as a whole is not mature enough to cope with the complexities and uncertainties of the modern world and so its future positive development is placed in jeopardy.

Biology provides a useful framework for showing that indeed most facets of existence are ambiguous - that so called "facts" of science are by no means immutable and "change" as science progresses; that observations of phenomena are themselves uncertain; that multiple explanations can be provided for events; that theories about the nature of the universe are little more than intelligent guesses based on evidence which is itself open to challenge - and so on.

The major causes of societal breakdown include the blind adherence to particular points of view; to a belief that "facts" are immutable and not open to challenge; to the unquestioning acceptance of authority; to suspicion and prejudice about those holding opposing views or belonging to dissenting cultural minorities and to resort to aggression and violence rather than reasoned analysis and negotiation in the resolution of conflict. These phenomena stem from immaturity. It is important, therefore, for biology teachers to establish the links between the ambiguities within the "facts" and processes of biology itself to the ambiguities within society as a whole and to help students cope with ambiguities, not only in the science classroom, but also in day to day living.

ii) Examples of Content

Example 8.40: Ambiguities in science

School System: -
Approach: *An essay for teachers on the changing nature of scientific facts*
Source: *Mayer, William V. Putting Science Into Biology: The Role of Biology in Exploiting Science. A paper presented for the annual meeting of the International Union of Biological Sciences Commission on Biology Education. Colorado Springs August 1984.*

Students must recognize science is a human activity subject to the frailties of all human endeavor. Science makes mistakes, but it is unique among disciplines in that science corrects its own mistakes ultimately. Huxley felt science was refined common sense. It has been spoken of as organized knowledge, but most are in agreement that science is a product of curiosity, the curiosity of humans who seek satisfaction in knowledge of the world for its own sake. Cats have been said to be killed by curiosity, but science can only be killed by lack of curiosity. Science works through a wide variety of methods. Methods used, in turn, are those that have been found to work, to yield enduring and sound explanations. Science attempts to discover new facts about the universe but, more importantly, to discover theoretical schemes that explain these facts and reduce them from an array of endless diversity to a unity of relationships.

However it is important to understand that facts can change. The fact that the sun went around the earth was changed by Galileo to the earth going around the sun. Theories change based on new knowledge. They may be discarded completely, as Darwin's theory of Pangenesis, or modified with new knowledge as the germ theory of disease. Teachers and students alike must recognize that the only constant in science is change. We do the discipline a disservice when we act as if our facts are immutable and our theories unchanging. This gives the impression of a scientific dogma and I think it's fair to say that one thing science is not is dogmatic. The history of science is replete with incidents of a single individual with the weight of evidence behind him changing the entire scientific outlook on a given topic. Think what Einstein's theory of relativity did to Newtonian physics. Think of the vistas that DNA has opened for further research.

Unfortunately, too many texts and too many teachers are not only unprepared for change, but actively resist it. One cannot overestimate the attraction of the status quo. I've actually had teachers tell me that they did not want to accommodate to new knowledge because they were competent and confident in the materials they were teaching and saw no necessity to change to some passing new data which might, in turn, be displaced. They were the seekers of verities, and for decades found comfort in systematics and morphology because names of organisms and structures seemed almost immutable. However true this might be for gross morphology, systematics has certainly undergone great changes. Instead of all living things being divided as to whether they are plants or animals, minimally we must now consider five kingdoms and, within a relatively short time, still additional ones. Biochemical systematics, a field virtually unknown at the beginning of this century, has achieved a great importance. Continental drift, punctuated equilibrium, and other new concepts have had a revolutionizing effect on the field of systematics that used to be the safe haven for the memorizer.

Science is a changing enterprise but, unfortunately, we have prepared neither our students nor our teachers for change. Instead we have acted as if a body of knowledge exists which, if committed to memory, imparts the process of science. Nothing could be further from the truth. Science is not mastered by osmosis, nor is it likely to be comprehended by mastering its minutiae. If an understanding of science is a desideratum, then teaching must lead to that understanding. It will not be achieved as a spin-off of a course that is essentially a rhetoric of conclusions. It can be achieved through courses that are conducted as a narrative of inquiry. Emphasis must be on how is it that we come to know what we now know? How did this or that discovery come about? What was involved in developing the germ theory of disease - how, for example, did Koch arrive at his postulates? Is science, and are scientists infallible? Are we teaching that science makes mistakes, but it is scientists who catch these mistakes and ultimately rectify them? Do we have students formulate hypotheses about a phenomenon based on their own observation or reading? Do we discuss the strengths and weaknesses of a hypothesis? Do we ask students to evaluate data for and against a given statement? Do we inform students of exceptions to the rule? Do we point out how our understanding has changed with the accumulation of data over time? Do we incorporate the transient nature of knowledge? Do we involve students in decision making? Do we hold discussions inviting the contribution of a wide variety of opinions and observations? Do we insist that there is one right answer and that all others are wrong? Do students know what truth is in science? And what is really ever proven beyond shadow of a doubt? Such topics as these are far more likely to give the student a comprehension of the process of science, how science works, its strengths and weaknesses, and the validity of its conclusions than work based on memory and regurgitation upon command. No classroom period should go by without an explication of how whatever is being discussed exemplifies science and the work of scientists.

Example 8.41: Alternative interpretation of ambiguous data

School System: USA junior secondary school science
Approach: Simple educational games to encourage students find alternative explanations for ambiguous situations
Source: Shepardson, Richard D. "Simple Inquiry Games" Science and Children Volume 15 No 2 October 1977 pp 34-36.

SIMPLE INQUIRY GAMES

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THIS SERIES of games is designed to improve decision-making skills. The activities provide an opportunity for students to ask questions, to organize data, to generate and test hypotheses, and to reach consensus with subsequent action.

As in all inquiry activities, the teacher places the students in the active role. There should be considerable student-to-student interaction, and the teacher should be in a passive or responding role

The games start with the teacher posing a problem. Constraints direct and structure student questions. To reach a solution, students gather data and test various hypotheses. The students are challenged to think, to trust their thinking, and to act accordingly.

Most of these games are suitable for both the primary and intermediate grades. They are designed for small groups of five to ten students, but can be used with the whole class as "fillers."

The students are required to ask questions which can only be answered by the teacher with a "yes" or "no" response. This forces the student to structure the path of inquiry.

Playing the Game

A picture presents a problem situation. The picture is partially covered so that only a limited amount of data is given to the students. They are then challenged to develop ideas (hypotheses) as to what is happening. Students pose questions which can be answered with a yes or no response to get more information and test their hypotheses. Give student enough data initially to insure that the activity does not become a guessing game.

For the example shown in Figure 1, the students have enough data to develop ideas about what could be happening. The picture has been drawn in such a way as to suggest, but not photographically depict, who or what is involved. It is up to the students to ask questions to determine the facts ("Does Person A have a gun?" "Is B wearing boots?").

In this type of inquiry episode, it is important that the students use a systematic questioning strategy, and determine the facts before they try to test their hypotheses. After enough facts have been determined ("Is A a police officer?" "Is B wearing a uniform?"), they can test relationships. ("Is A trying to arrest B?") Many students will try to guess relationships before they know the facts.

Wait until the group decides they are satisfied that sufficient information has been gathered to explain the problem situation adequately. When they are satisfied with their theories, expose the other side of the picture and explain the situation. Then the teacher should lead an analysis of the students' questioning strategy. Some of the following questions could be discussed: How many questions did it take? What questions were important in solving the problem? Did we determine the facts before we started

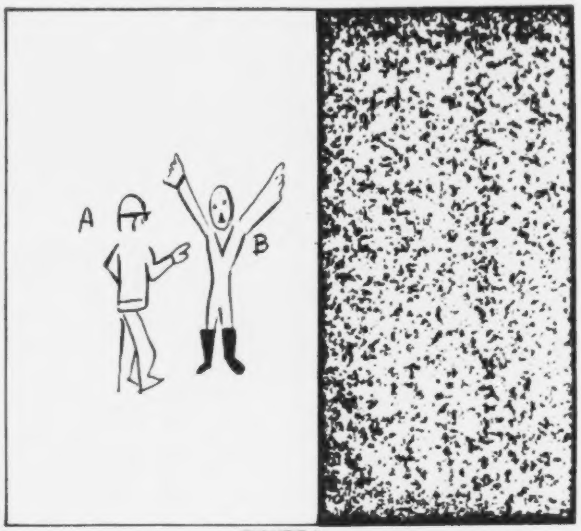

FIGURE 1.

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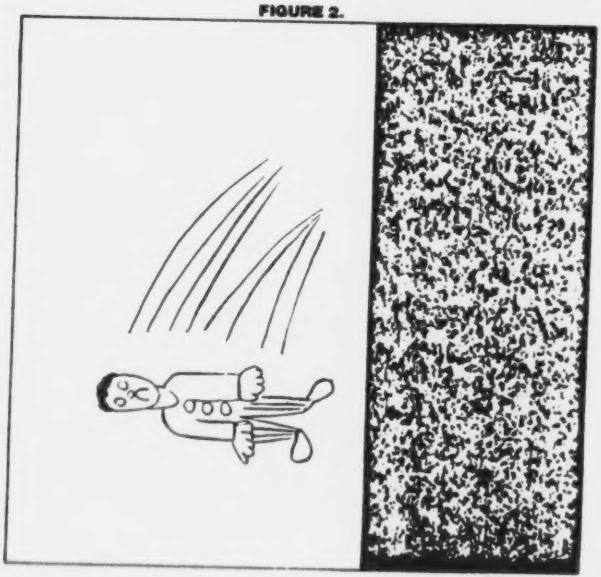
FIGURE 2.



RICHARD GUY

guessing relationships? Were questions repeated? Why? The analysis is valuable and should be an essential part of the activity.

The overhead transparency makes an effective presentation of the problem. Probably the best way of getting suitable episodes is to draw them yourself (remember the drawings should only suggest and not photographically depict situations). A situation can be shown in several stages. If the group is having trouble with questions, more data can be uncovered. If the students do not pick up the fact that B is wearing a uniform, part of the whip may be revealed; if that is not enough, show the chair.

Students can also create problem episodes. Figure 2 is a second grader's creation. Do you know what the problem is?

You can devise similar games such as "The Unknown Object," in which an object or picture of an object is presented to the class. They try to determine how it is used. Again, questions with yes/no responses are the only ones permitted. "The Unfinished Story" challenges the class to provide the possible ending of a story partially read to them. Questioning by the students continues until they are satisfied they have a fairly complete explanation of the ending.

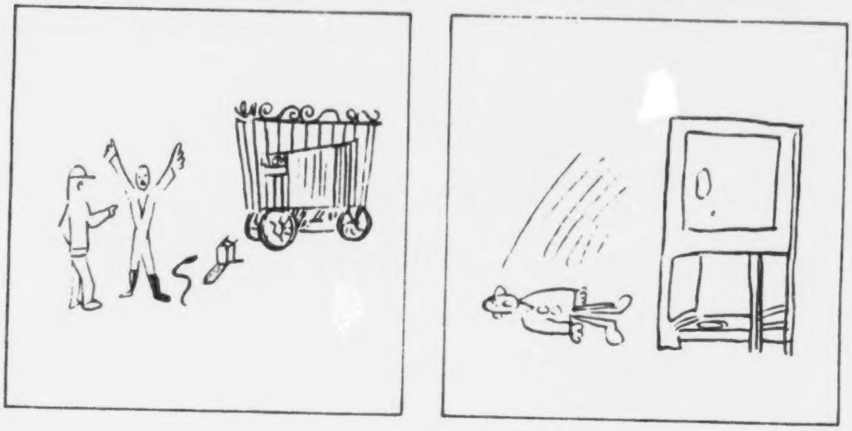
Techniques and Strategy

The games will go smoothly if you follow a few simple rules. Here are some suggestions:

1. Avoid repeating or echoing a student's question. When Silent Sal asks a question not heard by others, simply respond "yes" or "no" to see if the students are listening and involved in the activity.
2. Probe for clarification when you are not sure what a student is asking. Response to a question not fully understood communicates a certain degree of insincerity.
3. Limit the number of questions or the time of the questioning period to challenge the class further, after they are comfortable with the game's procedure.
4. Use a "round robin" strategy with each student asking a question in turn.
5. Allow a student to follow a train of thought in questions he or she asks. Students can keep asking questions until they say "pass," or can be limited to five questions each.
6. Challenge students to better their own average. ("I have three objects in a box. Let's see how many questions it takes to figure out what they are. Last week your average was 18 questions.")
7. In the "Unknown Object" game, do not allow students to guess at the object more than one time. (Is it an orange? Is it a grape?) They should instead ask questions regarding size, shape, and function to be certain what it is.

These games are beginning activities in encouraging students to think, to become better decision makers. Analysis of the questioning takes the activity beyond a mere game into the teaching arena.

FIGURE 3. Complete pictures for Figures 1 and 2. In the first case, the lion tamer is asking for help (the lion has escaped). In the second, a careless sleeper has fallen out of a bunk bed.



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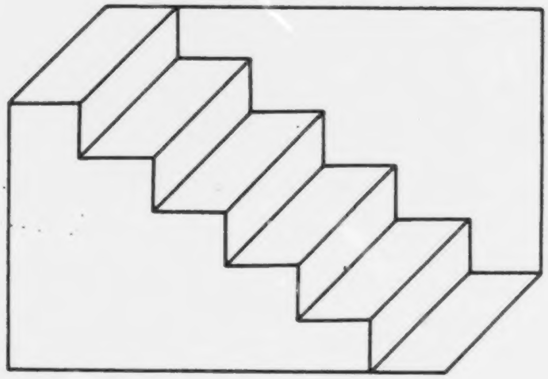
iii) Examples of Project and Test Questions

(Suggestions by author)

- Project. Ambiguous interpretations. Look hard at the following picture. Sometimes it will look like a staircase seen from above - that is the upper surface of the stairs will be visible. If you keep looking long enough you can see it in a different way. It will look like a staircase seen from underneath - that is the under surface of the stairs will be visible.



Form class groups to discuss the following questions.

(a) The strange example given above suggests that observations of exactly the same objects can sometimes be interpreted in very different ways. Yet modern science is said to be based on accurate observation. If the same observations can be interpreted very differently what reliance can we place on scientific truth?

(b) Can you think of examples in society where people can interpret the same event or phenomenon in different ways? Could this be one possible source of conflict in society? What could we do to reduce conflicts between people who interpret the same social phenomena in very different ways?

- Project. Changing views of biology. As science progresses ideas change and scientists tend to modify their views about what is factually correct and what is not. For example there have been many views about the nature of evolution and how it works. Before Darwin, Lamarck believed that characteristics acquired during the lifetime of an individual would be passed on to future generations. For example if a giraffe continually stretched its neck to obtain food from high branches its neck would become longer and this characteristic would pass to its offspring. Darwin showed that this was not the case and that differential survival was the key. Before Mendel's work on the particulate nature of inheritance it was believed that inheritance factors were blended in each new generation.

Choose an area of biology such as evolution, disease, heredity, growth and development, the physiology of the nervous system or any other area which especially interests you. Form research teams to review the following questions based on library reading.

(a) What were the explanations given by scientists to interpret some of the observations they made (i) over 200 years ago (ii) about 100 years ago (iii) 50 years ago (iv) today?

(b) Your research should have shown that scientific "truth" changes as scientists obtain more and more information. What does this suggest to you about the nature of science? Does science consist of an unchanging body of facts or can facts change?

(c) In society many people tend to want to keep things the same and they resist change. Frequently they appeal to an authority to say which is a correct "fact" and which is not a correct "fact". Is this realistic? If scientists continually change their minds about the rules of science how can we be sure of the truth about what people say should be the rules of society? If we realize that the rules of science and the rules of society came about from a consensus viewpoint and not from some unchanging authority, then what can we do to make sure the rules are the best for society as a whole as well as for its individual citizens, no matter how different they may be?

. Test Questions

1. What do you understand by the term "theory" as it is used in science? Describe an example from biology of how a theory can change as scientists obtain new information. [Write four pages]

2. Is science entirely "objective" and value free? Explain your point of view. [Write three pages]

3. Write ten lines on each of the following:

    (a) Explain the difference between observation and hypothesis in biology.

(b) What can scientists do to make sure their observations are as accurate as possible?

(c) Is it possible for two scientists to draw totally different conclusions from the same observation. Explain your point of view.

(d) In day-to-day life people can find very different explanations for the same events which happen in their daily affairs or in the affairs of society as a whole. Describe an example and write a few sentences about how the different explanations could be justified.

4. (a) Are scientists totally free of prejudice and bias in their search for new knowledge? Explain.
[Write two pages]

(b) In society people frequently make judgements about the behaviour of others eg. about minority cultural groups, new migrants, homosexuals, the unemployed. How can they be sure that their judgements are as fair and unbiased as possible?
[Write two pages]

8.11 Biology and Peace

i) Rationale

Science, and especially biological science, can make significant contributions to both the study and promotion of peace. School biology programmes, however, rarely, if ever, touch on this vital aspect of human welfare.

As in the case of "health", "peace" is usually defined in the negative. As we have seen (Chapter Six, Section 6.4), "health" was usually defined as the absence of disease but is now defined positively as "wellness". The main entry definition of "peace" in most dictionaries is "absence of war" but a positive approach would define it more in terms of harmony, tranquility and justice for all. Defined in this positive way it is easy to see that biological studies at school can help in the understanding of peace and can contribute to promoting peace.

Peace is important at all levels of society - individual, family, local community, nationally and internationally. It rests largely on aspects such as good health, especially mental health, cooperative behaviour, tolerance, rational analysis of problems, the harmonious resolution of conflict and a willingness to live with and understand complexities and ambiguities in all aspects of society. Many of these aspects can be approached through the teaching of biology and several examples have been presented throughout Chapters 6, 7 and 8 of this book.

What is needed in the specific case of peace studies, however, is a direct application and focus of these aspects on developing an understanding of the characteristics of peace and its role in ensuring the wellbeing of humankind.

One approach is to begin with purely biological aspects such as the characteristics of cooperative behaviour in nature; the balance of nature; the origin of differences, variety and individuality; interdependence studies; cultural evolution; the need for all people to act collectively to conserve resources and to protect the environment of the planet.

Another approach is through behavioural studies so that aspects such as conditioning, the satisfaction of needs, insight, modelling, the origins of aggression and so on are examined and related to the issue of peace.

A third approach is to review the role of science and scientists in society. Some attention could be given to matters such as scientific accountability, the roles and responsibilities of scientists, cooperation between scientists and the characteristics of the global scientific community.

Finally peace studies can benefit greatly from the consistent application of the rational processes of science. Problem-solving techniques can be applied to cases where peace has been the outcome and the cases can be drawn from all levels from the family perspective to the international arena. Cases can also be examined where the peace process has been a failure and replaced by confrontation, violence and even warfare.

The failure of biology education to face this key issue is surprising since at the macro level the very continuity of our species is at stake, and at the micro level an harmonious, tranquil and just life style for all is at the core.

ii) Examples of Content

Example 8.42: Definition of peace

School System: *Australia. University course in Peace Studies for students of Education*
Approach: *Presentation and comment on a dictionary definition of peace*
Source: *Macquarie University Educ 254 Peace Studies Independent Learning Package. Sydney: Macquarie University School of Education 1988.*

Definition

The following definition is from The Macquarie Dictionary. Note how complex and far-reaching the dictionary definition of 'peace' actually is. Note also the large number of meanings offered and the recurrence of key words like tranquil, calm, silent:

peace ...

1. .... freedom from war or hostilities
2. .... an agreement between contending parties to abstain from further hostilities
3. .... freedom from strife or dissension
4. .... freedom from civil commotion; public order and security; a justice of the peace
5. .... freedom from mental disturbance: peace of mind.
6. .... ease of mind or conscience
7. .... a state of being tranquil or serene.
8. .... a state conducive, due to, or characterised by tranquility or calm
9. .... quiet; stillness; silence
10. .... hold one's peace, to remain quiet; to keep silent
11. ..... keep the peace, to refrain from creating a disturbance
12. ..... make one's peace, to effect reconciliation for oneself, or for another person
13. ..... make peace, to arrange to stop hostilities; to end war . . .

With this definition before us, we may note immediately what some observers have called the 'minimalist' definition of peace. When most people define peace, they think in terms of definition 1. above, "freedom from war...". In fact, of course, peace is much more than simply freedom from war. We have all observed situations which were far from 'peaceful' but which could not be characterised as a state of actual warfare. The School of Peace Studies at the University of Bradford in West Yorkshire has pointed out:

> Peace is taken to mean something more than the mere absence of war because, although war may be the greatest scourge, its absence does not guarantee that human beings necessarily live in tolerable conditions; under 'peaceful' conditions they may indeed be treated unjustly and oppressively. By peace (or peaceful relationships to use a more precise term) we mean a positive combination of justice with a lack of violence....

Example 8.43: Science and the prevention of war

School System: -
Approach: Extract from an essay for teachers and curriculum workers on the role of science in maintaining peace
Source: Perutz, M.F. "The Impact of Science on Society: The Challenge of Education" in Lewis, J.L. and Kelly, P.J. Science and Technology Education and Future Human Needs. Oxford: Pergamon Press for the ICSU Press 1987 pp 17-56.

Science and Politics

Can science do anything to lessen either international or national tensions? Science is just knowledge and has no national content, but Karl Popper, a philosopher who has given much thought to the methods of science and their application to society, has shown that science can make at least a modest contribution by guiding people towards a scientific attitude to political problems. In a study of the history of political science, called "The Open Society", he attacked those philosophies which later became recipes for tyranny". All such philosophies have invoked laws according to which human society is bound to develop along certain predetermined paths. Plato pictured that path as a degeneration from the ideally perfect state and suggested that this degeneration must be arrested by the authoritarian rule of the wise few over the stupid multitude. George Orwell's *Nineteen Eighty-Four* is a brilliant caricature of Plato's Republic. According to Karl Marx's historical laws, industrialisation is bound to lead first to class war, then to the victorious revolution and dictatorship of the proletariat, and finally to the withering away of the State.

Popper starts from the premise that society is too complex a fabric to derive from its past any historical laws on which to base prophecies about its future. Anthropological research has shown that, contary to Plato, primitive societies are far from being models of moral perfection, and their social systems have generally remained static. Contrary to Marx, revolutions have occurred only in agrarian societies subjected to feudalism, while in highly industrialised ones the working class has tended to merge with the bourgeoisie. In fact, all so-called laws of history enunciated in the past have been falsified by events. Popper argues that the future depends only on ourselves and not on any historical necessity. Hence there is no law that makes either international war or national class war inevitable. It is up to us to see that they do not happen.

Lord Acton has said that democracy consists of forestalling revolution by timely reform. Popper argues that such reforms should be undertaken in the spirit of science where knowledge is only provisional and natural laws are regarded as hypotheses conceived to be tested experimentally. No hypothesis can ever by fully proved, because there might always be an experiment that falsified it. Defined like this, Galileo's law of gravitation is scientific but Freud's axioms of psychoanalysis are not. Experiments may force us to modify our original hypothesis so that gradually it approaches nearer and nearer to the truth. As Peter Medawar put it, "scientific reasoning is a kind of dialogue between the possible and the actual, between what might be and what is in fact the case". Popper argues that political, economic and social problems should be approached in the same pragmatic manner rather than by dogma. Since human society is exceedingly complex, the outcome of even the best-planned reforms will always be uncertain. Only gradual and non-violent changes have any likelihood of producing the results that are desired, and even then they may be accompanied by adverse and unforeseen side effects, rather like those of a new drug. Popper suggests that the social sciences should learn to predict such side effects, and that politicians and administrators should continually modify their policies in the light of them. Such an open-minded approach is possible only in the atmosphere of free discussion of a democracy.

In Italy, many young people say, like Mourlan in Roger Martin Du Gard's *Les Thibaults*, "Everything has got to be smashed to start with. Our whole damned civilisation has got to go before we can bring any decency into the world". A young Italian scientist living comfortably in Switzerland recently said to me, "Italian universities are so rotten that you have to wait for their collapse before you can start building decent ones". He should have known better.

Popper showed that such a "clean state" policy is unlikely to produce the desired result because destruction of the social fabric also destroys the institutions and moral values, the very decency on which a new improved society could be built. Popper's arguments have been confirmed by the disastrous results that followed when such a policy was actually carried out by the Communist fanatics in Kampuchea. It led to the killing of 2 million people, to famine, disease and invasion.

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Science is the triumph of reason. Bertrand Russell has said:

> "Rationality, in the sense of a universal and impersonal standard of truth, is of supreme importance, not only in ages in which it easily prevails, but also, and even more, in the less fortunate times in which it is despised and rejected as the vain dream of men who lack the virility to kill when they cannot agree".

There is no war that would make the world safe for either capitalism or communism, or for any militant creed or race. The dangers of nuclear war are infinitely greater than those of accidents at nuclear power stations. A single thermonuclear bomb could kill several million people, many of them by a slow and terribly painful death; it would make 20,000 square miles uninhabitable for a month, of which 1,200 would still be uninhabitable after a year[40]. Survivors in shelters would have no place to go that was not lethally radioactive and nothing to eat or drink that was not radioactively contaminated. The Soviet Union and the USA each have about 10,000 such bombs and are constantly building more, enough to kill most of each other's populations and to make the greater part of their cultivable lands infertile and uninhabitable. Militarists and extremists in both these countries are now trying to shift their strategic policies from deterring a nuclear war to actually fighting a "limited" nuclear war in Europe with tactical nuclear weapons. In other words, rather than destroying each other, they are planning to destroy Europe. It is unlikely that such a war would remain limited; it would soon escalate into a war with strategic weapons and would destroy most of the civilized world.

Everyone with common sense must help to prevent such a catastrophe. Young people who now demonstrate against nuclear power stations would do better to demonstrate against the physicists who keep pressing new weapons on the military, against the industrialists who compete for their manufacture, against the strategists who devise new targets for the weapons, and against the politicians who believe that these weapons will enhance their power[41].

A nuclear war would destroy everything that has been built up over centuries without giving us any control over what, if anything, will rise from the ashes. We must work for the application of science to peace and a juster distribution of its benefits to mankind. In this process science education has much to contribute.

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Example 8.44: Scientists as experts for peace

School System: -

Approach: *Background reading for teachers on the potential role of scientists in maintaining peace*

Source: *Broda, E. "International Stability in the Responsibility of the Scientist and Technologist" in Frazer, M.J. and Kornhauser, A. Ethics and Social Responsibility in Science Education (Science and Technology Education and Future Human Needs Volume 2). Oxford: Pergamon Press for the ICSU Press 1986 pp 57-66.*

Experts for peace

Well-meaning lay persons often ask why scientists (or generally: experts) on war work do not go on general strike. Now quite apart from the fact that such action would not affect existing weapons, sufficient for tremendous overkill, in the hands of the military it is quite clear that few experts indeed would follow a call. Too deep is, on one ground or another, the personal involvement, as has been explained. Much as one respects and praises individuals who as conscientious objectors have the courage to quit, their step does not provide a solution to the problem.

Nevertheless, the contribution of scientists to the world movement for peace has been outstanding. Their warning voices have been heard by many men and women, including some open-minded statesmen. Niels Bohr has been mentioned already. Cecil Powell and Frédéric Joliot were other Nobel Prize winning physicists who devoted much of their later lives to the struggle for peace and the education of the public. Linus Pauling, Nobel Prize winner in chemistry, later was awarded a second Nobel Prize for his work for peace. Bertrand Russell and Albert Einstein were the founding fathers of the Pugwash Movement, uniting experts, mostly natural scientists, from East and West (Rotblat, 1982b).

The Pugwash Movement, named after the Canadian village where its first meeting took place in 1957, has been active for a quarter of a century in favour of coexistence, detente, disarmament and peace. In conferences, symposia and workshops the members of Pugwash, many of them eminent, have been applying their technical competence and their good will in the search for peaceful solutions to the acute world problems. Many Pugwash members enjoy the confidence of their governments, and so their suggestions have a relatively good chance of being accepted. The discussions within Pugwash contributed to the all-too-few international agreements reached in the period of detente, including the Partial Nuclear Test Ban and the Nuclear Non-Proliferation Treaty.

Recently Pugwash has been supporting a general pledge of all nuclear weapons countries against the first use of these weapons as well as a freeze treaty forbidding the production, testing and deployment of further nuclear weapons. Such actions would facilitate steps in the direction of disarmament. In 1981 a Pugwash Declaration of Dangers of Nuclear War has been signed by 111 Nobel laureates, the large majority of all laureates in the natural, including the medical, sciences. In this Declaration a desperate call is issued to the world, and specifically the no-first-use pledge and the nuclear freeze are supported.

In the activities against nuclear war scientists rather then technologists have been prominent, and among the scientists mostly academic scientists. These facts reflect the greater difficulty faced by experts employed by industry. They are less able to plan their time and join time-consuming groups than their colleagues in universities. Moreover, the whole climate in industry is less favourable to independent activities with political repercussions than that in universities. Experts in industries would in many cases endanger their positions and careers by taking part in antiwar activities even if their firms did not make arms themselves. To some extent such difficulties also affect engineers and technologists in universities with their links with industry. In view of the tremendous importance of the movement for peace, these difficulties should not deter an approach to engineers and technologists.

They could, on the basis of their professional knowledge and their capacity for rational problem solving, make a most important contribution to the maintenance of peace. They could raise their warning voices and would be listened to by the public. In this respect a comparison is possible with the rapidly spreading movement of the medical doctors against nuclear war (International Physicians for the Prevention of Nuclear War — IPPNW). Thus technical experts would serve the peace movement.

Moreover, another challenging task exists. Professionally, engineers are familiar with stability problems. They know the criteria needed to judge and ensure stability in material systems and networks. It would be a great step forward if engineers devoted themselves to studies on stability and instability in international life.

In the view of the present author, it will be in the best interest of all countries to search not only for their own security, but also for that of all other countries, including possible adversaries. This concept may be called the security partnership. As explained elsewhere, the "worst case analysis" where both boundless technical capacity and boundless evil will are attributed to adversaries is pernicious. The acceptance of the security partnership idea requires not only technical competence, but also good will, tolerance and patience. Peace and the stability of the world cannot be ensured on a technical level alone but requires a new morality. The human factor is essential.

Reference: Rotblat, J. "Movements of Scientists Against the Arms Race" in Rotblat, J. (Ed) Scientists, the Arms Race and Disarmament A Unesco/Pugwash Symposium. London: Taylor and Francis 1982 p 115.

Example 8.45: Peace begins at home

School System: USA teacher education programmes
Approach: An activity for a teachers' workshop on aspects of international education
Source: Kinghorn, Jon R. and Shaw, William P. Handbook for Global Education: A Working Manual. Dayton Ohio: Charles Kettering Foundation 1977 pp 53-54 and 94-95.

Activity Peace Begins at Home (30 Minutes)

This activity is designed for educators but could be modified for an organization.

Assume that two of your school's goals are:

- Assist students to have a stronger commitment for world peace than some adults have at present
- Reduce conflicts between students and between students and teachers

What can be done? This exercise presents new ideas for consideration.

Give each participant a copy of "Peace Begins at Home" (Appendix IV). Participants each complete the activity based upon their own reactions to the issues and then compare ideas with the other small group members to hear their reactions. They decide on the eight most effective issues and rank them, the first being the most effective. Then they mark those that would have no impact or those that would actually be harmful or counterproductive. Space is provided for listing their own items. Encourage some serious consideration of the ideas and the possible strategies for implementation. What barriers could be expected? Would the trade-offs be worth the goal of enhancing world peace and reducing conflict? What other responses would be appropriate for encouraging world peace? Have the small groups develop their own set of responses which will be posted for the total workshop. Suggest that this activity could be an idea to implement for a specific school-wide project over the entire year.

APPENDIX IV: PEACE BEGINS AT HOME

Top Eight Most Effective	No Impact	Most Harmful	Identify those items most effective in helping boys and girls to grow up having a stronger commitment to world peace.
			1. More competitive sports and other competitive activities.
			2. More adventurous activities (e.g., camping, hiking, sailing)
			3. All staff make a commitment to never put down or be negative to a student.
			4. History to concern itself more with great individuals of peace than heros of war.
			5. Geography and history to be more on the topic of mankind rather than one's own country.
			6. More teaching about causes of war and violence.
			7. More emphasis on family activities within the school program.
			8. Students at all academic levels required to participate in projects of caring and serving in the local community (nursing homes, invalids).
			9. Cause students to know, understand, and communicate with other students in the school who have different value patterns and cultural differences.
			10. More effort to help students understand the life style of people in other parts of the world. (Greater study of other religions, economic systems, cultural patterns, family patterns.)
			11. More effort to recognize how our society might be viewed from other societies.
			12. More effort to teach good listening skills.
			13. Require more specific tasks of students with fewer options so they learn to follow rules and requirements.
			14. Have the school remove corporal punishment and pledge themselves to nonviolent solutions to local conflicts.
			15. Encourage study of the lives and teachings of people like Ghandi, Plato, Socrates, Jesus, and St. Augustine.
			16. Have frequent speakers come to school to speak about global issues on war and peace, i.e., local congressman, army recruiter, minister.
			17.
			18.
			19.
			20.
			21.

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iii) Examples of Project and Test Questions

. Project. Issues of war and peace.

Discussion topics for groups:

1. *Issues of War and Peace*

1.1 What is the role of nuclear weapons in maintaining peace?

1.2 To what extent may a scientist ethically do research on arms?

1.3 A young government scientist thought he was working on *defence* aspects of germ warfare, but realized that his results could be used for *offence*. Should he resign knowing that this would put his young family at risk, and that almost certainly another scientist will be appointed to continue his work?

1.4 Is it ethical to spend resources on defence while many people of the world suffer from hunger and disease?

1.5 Should priority be given to scientific research directed to meet the immediate needs of people?

1.6 How much right do individual nations have to militarize outer space, to mine the oceans of Antarctica? Or are these the "common heritage of human-kind"?

1.7 Can individual citizens have any influence on the arms race?

1.8 What are the economic and social consequences of continuing the arms race?

1.9 What conditions, both nationally and internationally, contribute to the arms race?

Source: Frazer, M.J. "Appendix 2. Some Suggestions for Students' Discussions of Moral Dilemmas" in Frazer, M.J. and Kornhauser, A. Ethics and Social Responsibility in Science Education (Science and Technology Education and Future Human Needs Volume 2). Oxford: Pergamon Press for the ICSU Press 1986 pp 257-259.

(The remaining project and test questions given in this section are suggestions by the author.)

. Project. Scientists and peace. Go to the library and make a summary of the causes and main events of the following wars.

(a) Second World War
(b) Vietnam war
(c) Iraq-Kuwait war

Form discussion groups to review the following questions.

(a) Could biologists, in their role as scientists, have made any contributions at all to preventing these wars?

(b) Once the wars began, did science, and especially biological science, play any role in moderating the duration and violence of the wars?

(c) To what extent should biologists, as scientists, involve themselves in matters such as war and peace?

- Project. Analysis of case studies. Form discussion groups and review the following issues.

  (a) Can peace be studied in the same way a science like biology can be studied?

  (b) One way of trying to understand peace is by examining case studies of success and failure of the processes of peace.
  Discuss how the processes and methods of a science such as biology could help in investigatng such cases. Give examples.

- Project. Involvement in peace making. Discuss the following.

  (a) Is the promotion of peace the concern of everybody or just the concern of politicians and diplomats. Explain in some detail.

  (b) "Science is the product of humankind and is not free of human values." If that is the case what types of scientific values should be promoted in order for science to make a stronger contribution to world peace?

- Test Questions

  1. Dictionaries generally define peace as the absence of war, but that says what peace is not rather than what it is.

     (a) Suggest a positive definition of peace which explains its characteristics.
     [½ page]

     (b) How could a knowledge of biology contribute to the promotion of peace:
     (i) in the family
     (ii) throughout the community
     (iii) internationally?
     [Write one page on each]

  2. How could biologists, in their role as scientists, contribute to international peace?
     [Write five pages]

  3. "One aspect of peace is 'inner' or personal peace. This implies that individuals who have peace of mind are also mentally healthy."

     (a) Do you agree with this idea? Explain your answer.
     [Write two pages]

     (b) How can a knowledge of biology contribute to mental wellbeing?
     [Write two pages]

4. The following are some propositions about the way animals and plants live together in the natural world.

   - various species live together in balanced communities
   - predators kill prey for food and not for pleasure or to exert power for its own sake
   - all organisms get energy either directly or indirectly from the sun
   - plants and animals are adapted to the conditions of the environment in the places where they live.

   (a) For each of the above describe an example of what occurs in nature.
   [Four pages]

   (b) Can any of these examples provide lessons for humankind about the maintenance of peace between individuals, communities and nations? Explain your point of view.
   [One page]

5. Peace in a family can be disrupted by bullying, jealousy and intolerance. Sometimes families are put at risk by these disruptions and may not be able to hold together. Could a knowledge of biology help a family counsellor advise a family at risk about how to overcome serious disruptions such as those listed above? Explain your answer.
   [Write about five pages]

8.12 Living in One World

i) Rationale

As our planet becomes more crowded and as pressure on resources and on maintaining the quality of the environment and of the human condition become so much greater, it is increasingly apparent that our survival depends on our learning to live together in cooperation and harmony. Biology education can contribute a great deal to increasing understanding of this issue and can therefore help in fostering a spirit of tolerance, cooperation and global understanding.

The US educationalist James M. Becker believes that the entire curriculum of the school should focus on global education. It should encourage students to "think for themselves as participants in a world society" (21). Whether or not such an integrated curriculum is eventually introduced or whether or not subjects continue to be taught separately, biological concepts and principles must make a major contribution to global education.

A world centred approach should deal with issues such as the following (22).

1. The biological and cultural basis of human diversity.

2. Interactions between the social and natural environment world wide and their impact on human relationships eg. feeding the planet.

3. Individuals as members of (i) the human species (ii) a nation (iii) the planet as a whole. Focus on participation in a world society.

4. Humankind as one species sharing the same resources of the same planet.

5. The whole planet as one system consisting of interacting subsystems which must be managed accordingly.

6. The world as a laboratory for the study of human experience and for building new knowledge.

7. Mutual understanding. If we are to live together we must all understand one another - especially our behaviour and our various roles in political, social and economic situations.

8. Humankind as one species in an interdependent web of life. Our responsibility to guard and protect non-human species.

9. The direct or indirect involvement of all individuals in international transactions in their daily lives as consumers, producers, citizens, workers, politicians and so on.

10. The complex network of linkages and connections between individuals, organizations and nations eg. tourism, trade, education, communication systems, scientific exchange, military aid, economic aid and foreign policy.

11. The many organizations which exist to foster international cooperation and linkages. These include non-government agencies, multinational corporations, voluntary groups and social clubs, professional associations, governments and international organizations such as UN and its agencies such as Unesco, The World Bank, the international scientific unions, OPEC and OECD, international programmes such as "Decade of the Tropics" and "Man and the Biosphere".

Clearly many of these issues are biologically based or have links with biology. It is important, however, that the global educational implications of concepts such as human diversity, cultural evolution, human behaviour and development and so on be stressed at every opportunity.

ii) Examples of Content

Example 8.46: International perspectives for biology education

School System: Secondary education world-wide
Approach: Report of an international survey of science educators on education about issues of global significance. Background reading for teachers and curriculum workers in biology
Source: Bybee, Rodger W. "Human Ecology and Teaching" in Unesco: New Trends in Biology Teaching Volume V. Paris: Unesco 1987 pp 145-155.

AN INTERNATIONAL PERSPECTIVE

To what degree does an international group of science educators identify human ecological problems as important components of study in education programmes? This is the central question addressed in this section. In the spring of 1984, along with a colleague in the Science, Technology and Public Policy Program at Carleton College, I designed and conducted an international survey of science educators.[1] This survey extended earlier work of a similar nature in which scientists and engineers (Bybee, 1984*a*), citizens (Bybee, 1984*d*) and college students (Bybee and Najafi, 1986) were surveyed.

The aim of the survey was to identify and prioritize important global problems and to establish a linkage between these issues and education. Twelve broad categories of problems were used in the survey. The results included the respondents' ranking of the twelve items from most to least important and a ranking of how science educators think the problems will change by the year 2000. They were also asked about the importance of studying the human ecological problems in schools, the importance of studying the problems at different grade levels and the instructional time that should be devoted to human ecology problems.

The survey was sent to 325 science educators; 262 surveys were returned for a response rate of 80.6 per cent. In general, the respondents were science educators working in colleges or universities; they were forty-one years of age or older; and they had the doctorate degree. The average number of years of involvement in science education was twenty-one. The respondents represented forty-one countries. Based on the survey data the following can be stated:

- Global problems related to human ecology can be prioritized for study. While the top ranked problems will be the recommended focus of study, it should be noted that respondents consistently indicated that these problems are interrelated, interdependent and important to study. The top ranked problems were:

  World hunger and food resources
  Population growth
  Air quality and atmosphere
  Water resources
  War technology
  Human health and disease
  Energy shortages
  Land use
  Hazardous substances
  Nuclear reactors
  Extinction of plants and animals
  Mineral resources

- Global problems will probably be worse by the year 2000. The exception to this view is human health and disease. Deterioration of the human habitat is not only cause for concern, it can serve as a rationale for education about human ecology. If some of the present trends are to be altered, education will surely have a role to play.
- Global problems related to human ecology are generally important to study in schools. There is, however, increasing importance across grades kindergarten to 12 or ages six to eighteen.

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[1] The Science, Technology and Public Policy Program at Carleton is partly supported by funds from the Alfred P. Sloan Foundation. I would like to acknowledge the support of Carleton College for this project and the specific contribution of Teri Mau and Vicki Miller to the design and analysis of the survey.

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- Global problems related to human ecology should occupy the following percentages as a minimum amount of instruction time: early years (ages 6-10), elementary school, 10 per cent; middle years (ages 11-14), middle school, 15 per cent; late years (ages 15-18), high school, 20 per cent; college, 25 per cent.
- Courses in which global problems are presented should be required of all students.
- The science and social studies aspects of human ecological problems should be integrated and taught in a single course.

This international survey serves as a link between human ecology and education. Science educators indicate which global problems are important, and they indicate that these problems ought to be included in education programmes. Science educators also provide some fairly specific recommendations concerning the amount of time devoted to human ecological problems, who should take courses that include global problems and how the science and social studies aspects of global problems should be presented. There is interest and support for the human ecology theme in biology education.

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Example 8.47: Global learning

School System: The United Nations University

Approach: Background reading for teachers. A discussion of an educational approach to addressing issues of global significance

Source: Ploman, Edward W. "Global Learning: A Challenge" in Taylor, C.A. Science Education and Information Transfer (Science and Technology Education and Future Human Needs Volume 9). Oxford: Pergamon Press for the ICSU Press 1987 pp 75-80.

This, in turn implies the need to develop the capacity for learning, at the individual level and, equally and often more importantly, at the level of groups, institutions and even societies. What do we know about how societies learn? Why is it that some ideas or phenomena seem to "catch on" without anything that resembles education or learning (e.g. the transistor radio) while others, however well-grounded, however well-promoted, seem to make no headway at all (e.g. disarmament)?

In this perspective, it seems clear that all societies—be they industrialised or poor, East or West of geographical or ideological divides—are ill-prepared to deal with a swiftly changing, increasingly complex and increasingly competitive world. It is a basic fact that, all stated intentions and all available knowledge to the contrary, we have failed to learn how to deal with the problem of poverty, most intolerably demonstrated in the current African crisis. Since there have been some 140 wars since 1945, mostly in developing regions, we still seem to admit war as a means of conflict resolution, particularly as long as our boys are not involved, and agree to make them increasingly murderous by putting some of our best scientific talent into the development of arms. "The march of folly", to use Barbara Tuchman's striking phrase, is reflected in that the best we can come up with to avoid the ultimate catastrophe is appropriately called MAD for "mutually assured destruction". What capacity have we developed to cope with the situation at the end of this century, with another two billion people crowded into a shrinking global village, already beset by violence, hunger, poverty, environmental deterioration, ungovernable mega-cities and threats to our survival not only from earth but also from space?

Learning Needs

The UN University has been entrusted with the task of improving the understanding of pressing global problems of human survival, development and welfare. Thus, one focus of its activities is on the changing realities that together make up global issues and the corresponding learning needs.

In general terms, it is obvious that we must learn how to manage global, complex systems while respecting the autonomy of the processes and elements within these systems. We need to learn how to manage interdependence not only of countries but also of issues at new and higher levels of complexity and vulnerability. In the process of interdependence we have all become more vulnerable. Changes at the international level are now interlinked with changes at the national and even sub-national level, politically, ecologically, culturally and psychologically. Changes in modes of production and consumption affect not only economies but also resource use and eco-systems. Thus, we need to learn how to understand and manage systems that are, in a global perspective, marked by profound change and thus by uncertainty, instability and unpredictability. We are facing a situation of global transformation where at the same time science and technology have brought about an extension of

The Concept of Global Learning

First, some indication should be given of what the concept of global learning is supposed to signify and how the UN University is trying to develop and apply this idea. The concept of global learning represents an emerging confluence of diverse trends in thinking and in practice: it is like an evolving web of ideas and activities. Drawing upon the admirable ambiguity of the English language, the term global learning can be seen as referring both to:

— learning about global issues and processes

— learning processes globally perceived

The concept "global" as used in this context cannot be equated with the traditional concept "international": it has deeper and wider connotations. It requires a complementary linkage of issues: horizontally not only across disciplines and professions but also across cultures, societies and ideologies; vertically across levels, relating the global perspective to the local, national, regional and international levels. The linkage between "globality" and learning can then be seen as the learning required to cope with global issues, from disarmament to development; thus, as Rector Soedjatmoko has stated in a recent lecture: we need to understand not only the learning dimension of development but also to consider development as learning, as something we learn rather than just do.

human power to the point where it could destroy our planetary habitat and civilisation as we know it. If this destructive capacity seems a certainty we do, however, also need to learn how to deal with situations of scientific uncertainty or even controversy where action—or non-action—might have long-term or even irreversible effects.

Such general global issues and learning needs are directly linked to the development, application and understanding of science and technology. In addition, this conference could provide the opportunity for identifying the specific learning needs related to its themes. There is, though, one dimension of the global learning concept that seems applicable to all the varied learning issues raised by these themes.

Inherent in the global learning concept is the need to learn how to generate, evaluate, select and share vast amounts of new, timely and relevant information, at all social levels, from the villager to the political decision maker. Relevant is the key word but relevant to whom? If for example, we need to learn how to disseminate scientific and technological knowledge in a manner which makes sense to the end-users, must we not first learn how to listen to the end-users? Thus, do we not need to go beyond "education" in the traditional sense as a one-way communication process to "learning" as an intrinsically two-way process of knowledge sharing?

Example 8.48: Global issues with ethical implications

School System: -
Approach: *Background reading for teachers. An extract from an article on ethics and social responsibility in science education*
Source: *Frazer, M.J. and Kornhauser, A. "Ethics and Social Responsibility in Science Education: an Overview" in Frazer, M.J. and Kornhauser, A. Ethics and Social Responsibility in Science Education (Science and Technology Education and Future Human Needs Volume 2). Oxford: Pergamon Press for the ICSU Press 1986 pp 31-36.*

Selected issues concerned with ethics and social responsibility have been grouped under nine headings.

1. *Arms race*

It is not just the horrific dangers arising from the production, storage and use of nuclear, chemical and biological weapons, but equally important is the terrible waste of material and intellectual investment. This investment should be redirected towards bridging the gap between developed and developing countries. Education should lead to a better understanding of the risks and wastes arising from the arms race and the manufacture of weapons of destruction.

2. *Population growth*

One of the major reasons for poverty in the world is population growth unrelated to economic development. In addition to striving for economic growth, education for family planning is urgently needed. At present the burden of birth control, often with inadequate methods, falls mainly on women. Research and social actions are needed to regulate the population growth and to place the burden and responsibility for birth control equally on men and women. Awareness of family planning should be one of the major goals of all science curricula.

The accumulation of population in big cities brings with it two major negative consequences: the use of fertile land and the construction of "human silos" — settlements in which little care is paid to the relationship between man and nature. Education has to develop responsibility for long-term oriented land usage and appropriate design of human settlements.

3. *Food*

Millions of the world's population are starving but to alleviate this problem by using pesticides, fertilizers, etc. in turn produces new problems. There is a danger of turning to short term solutions such as overfarming and overfishing. Education has an important role to play in highlighting social and ethical issues related to the production and distribution of foodstuffs. The balance between providing sufficient food and protecting the environment needs to be stressed. It is important that clear and correct information concerning food additives should be available.

4. *Health*

Drug production is mainly market-oriented. Over one billion people are suffering from tropical diseases but because they represent a poor market, there is insufficient development of appropriate drugs. It is a responsibility of all nations to ensure the prevention and cure of diseases in all parts of the world and the force of public opinion, well informed through education, must be an important factor.

As a nation develops, the number of old people increases. A positive approach towards old people so that they enjoy as active a life in the community as possible should be created in younger people. Education has an important role in developing an attitude of responsibility towards members of the community in need of help.

Experiments in the development and use of drugs and new medical methods and techniques, either with animals or with people, have both positive and negative aspects. These should be discussed in the context of ethics. There are also two sides to the prolongation of life. With medical advances it is possible to prolong life and certainly no one wishes to see a life destroyed; but on the other hand, there are problems at the individual level, e.g. the use of resources which might have been used for treating many other patients. It is not only in prolonging life that ethical issues arise over the deployment of resources in health care (e.g. the cost of heart transplants and kidney machines balanced against the need for curing and preventing illness in the population as a whole). These dilemmas should be openly discussed.

The issues of human fertilization (experiments on the human foetus, sperm banks, surrogate motherhood, etc.) also need to be part of a public debate, but this can only take place if people are properly informed through education.

The known facts about the dangers of drug addiction, alcoholism and smoking should be priority areas for school education.

5. *Environmental problems*

The risks to the environment (pollution of land, water, air and the upper atmosphere) arising from the activities of man are now well known. However, in science curricula, these risks need to be put into perspective. It is possible that a few people may die through the inappropriate use of pesticides, but this needs to be contrasted with the fact that millions will be saved from early death or disability from the scourge of malaria. The balance between desired and undesired products was illustrated in the diagram. In education, at school and for the general public, it should be pointed out that there are no absolutes about this balance. What may be an unacceptable level of pollution in one place may be temporarily acceptable in another if related to economic development.

Pollution does not recognize national boundaries. "Acid rain" raises an important ethical problem. Should not the general public, in those countries providing energy by burning fossil fuels, have enough information to understand that they are "exporting" sulphuric acid to other countries with disastrous effects on forests and lakes? This "export" can be controlled either by lowering demand or by consumers being prepared to pay more for energy. Industry, and the production of energy, brings other problems of social responsibility, e.g. the dumping of chemical, biological and radioactive waste. An important part of science curricula should be concerned with the protection and the improvement of eco-systems, and should develop an awareness that man must live in equilibrium with the environment.

6. *Resources and technology transfer*

An awareness of the responsibility for natural resources, including a long-term oriented approach towards their use for the benefit of the whole of mankind, should be a part of the goals of all science curricula. In the

transfer of technology there are a number of controversies concerned with: (i) the priorities of capital-intensive versus labour-intensive technology, (ii) the rights of licenser and licensee, (iii) the transfer of "dirty", or obsolete technology, (iv) the ways of overcoming low technology development within a short time, and so on.

Education about the ethical problems concerned with technology transfer is important so that the general public can be involved in decision-making.

7. *Information technology*

information plays a crucial role in production. It is also the basis for public decision-making.

Computerization has positive aspects such as more efficient storage, search and retrieval of information and the production of new information. On the other hand, it also brings dangers — an increased chance of central control over the population, the misuse of information, lack of privacy and opportunities for criminal acts.

Access to scientific and technical information is often limited not only by cost, but also by political decisions. This lowers the chances of the Third World to overcome the developmental gap and consequently represents an ethical problem.

8. *Human rights*

Every opportunity should be taken in science education to explain and develop proper attitudes towards human rights. In science lessons an objective approach will overcome the pseudo-scientific basis of prejudice, intolerance and racialism. Particular attention should be given to disadvantaged groups (ethnic minorities, refugees, immigrants, handicapped persons, etc.). The equal place and role of women in society is crucially important. Science education has an essential part to play in helping to bring women into creative processes in society. Women should not only have equal rights, but should also have equal opportunities to make contributions to development and technological innovation.

9. *Research*

To the majority of the population scientific research appears inaccessible. This is wrong — it is vital that the general public should be better informed so that it can contribute to decision-making. Ethical issues arise, for example, in experiments with animals, in research into genetic engineering, etc. The general public needs to know what is being done and

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why. What are the risks and what are the potential benefits? Only with this information, via science education, will public opinion be a powerful force.

The scientific community, as well as the general public, should be better informed about the priorities for funding fundamental and goal-oriented research.

The education and training of research scientists poses some difficult problems. Should the best post-graduate students from the Third World, studying at international centres of excellence, work on fundamental research, or should their training prepare them for solving the more immediate problems in their own countries?

Another important ethical problem is that of communicating science to the majority of people in a language they can understand. Scientists must leave behind their professional jargon, and communicate science in the natural language of the population.

Example 8.49: Themes for teachers' workshops in global education and an example of one workshop

School System: USA teacher education programmes
Approach: Suggested topics for teachers' workshops on global education. Description of procedures for one exemplar workshop
Source: Kinghorn, Jon Rye School Improvement Through Global Education A Guide to Four Essential Themes. Dayton Ohio: Charles F. Kettering Foundation 1979 p 39 and pp 58-59.

Goals:

- Understanding what a system is and how it operates
- Experiencing the insight that can be gained when one views the world as being composed of several distinct, but interrelated systems—i.e., economic, political, cultural, and ecological
- Understanding that many types of organizations are directly involved in global issues such as the private sector, churches, multinational corporations, national governments, and subnational groups such as cities and states
- Realizing that individuals, groups, and countries set examples that others may follow
- Identifying the international involvement of one's own community and state
- Understanding the many ways the United States and other nations of the world are linked interdependently
- Understanding that different lifestyles have different impacts on the earth
- Identifying the ways in which one's own activities affect the earth
- Understanding that personal and collective decisions made by Americans have consequences for people elsewhere in the world
- Understanding that actions often lead to unanticipated consequences that ramify over time
- Realization of the possible consequences for oneself and others who have different world views on issues when important global issues are at stake

Goal: Understanding that actions often lead to unanticipated consequences that ramify over time

Implications for Global Education

Seldom will actions have a single consequence. Actions tend to ramify. A single action spreads out into many areas. A decision to cut off imports or a decision to buy from a specific country is felt by many people in many areas.

A recent decision to cut imports of sugar in order to give American growers a better price seemed a simple action. Just a few of the consequences were:

- It generated many very hostile feelings and attitudes from those who export sugar.
- Unemployment increased among workers in the sugar industry of the sugar exporting countries.
- The standard of living dropped even lower in some of these countries.
- United States economic aid was increased to help with falling economies in some of these countries.
- Immigration increased to the United States.
- United States unemployment went up.
- Profits of United States companies which owned the foreign sugar industries decreased.
- Decreased profits resulted in a lower work force in the United States.

You are helping students gain a global perspective when you help them see that actions often have complicated results. Your examples do not have to deal with international events. Use examples from your content area to guide students to develop a way of thinking so they understand that more than a simple reaction will occur from a single action.

Suggested Ways to Respond

- From the newspaper select examples of actions taken and have students predict possible ways the actions could ramify.
- Have students review an action and think of questions that have not been asked about its many possible consequences.
- Give students an example of an action in your discipline and draw inferences as to how the action will affect other disciplines (for example, actions in science affect psychology, business, and other disciplines).
- Find examples of this goal within your content area.

Your Ideas

Implications for School Improvement

A school staff or individual teachers will generally make the best judgment *if* they take time to consider all the consequences of whatever action they plan. Trouble generally develops when time is not taken to think through what the effects are likely to be.

Often our actions turn out to foster the very things we are trying to avoid. Before an action is taken by a staff or by individual teachers, a list of possible consequences should be developed.

Suggested Ways to Respond

- Illustrate how an action by the total staff had an unexpected positive influence or an unexpected negative influence.
- Have students discuss with you the ways your actions in the classroom might ramify over a period of time.
- Before reaching a decision, brainstorm all the possible school policies or people that the decision could affect.
- Have students list the ways their actions have led to an unanticipated change in a teacher's behavior.
- Ask students to share experiences outside the school that resulted in unanticipated consequences.
- Ask students to share personal experiences which illustrate how their actions lead to unanticipated consequences.

Your Ideas

iii) Examples of Project and Test Questions

. Project. Human variability and diversity.
(Source: Cohen, David; Hill, Jennifer; McDonnell, Kevin, and Meyer, G. Rex *Biology Practicals for Senior Students*. Melbourne: Heinemann Educational Australia 1989 pp 143-152). [Also see Example 6.23]

EA6-6 Human populations

It is quite difficult to arrive at a definite conclusion about country of origin through a study of the features of one individual. This is because:

1 young people do not always exhibit all of the features they will have at maturity

2 characteristics such as body form and skin colour are inherited in a complex way (many genes are involved rather than just two). Thus you may be tall and slender whilst another member of your family may be short and stocky

3 many groups are difficult, as a whole, to classify

4 although there are many features of a person that can be accurately measured (e.g. fingerprints, blood groups, head and facial indices) most of your decisions will be based upon simple observations.

INQUIRY

To see if it is possible to discover one's own country of origin through a study of personal physical characteristics.

PROCESS OBJECTIVES

By the end of this activity you should be able to:

1 complete a table in order to detail your physical characteristics

2 from your table and given information propose your probable origin.

PROCEDURE

Select the alternative, in each of the following, which best fits you. Enter the details in the 'Personal features table' and compare these with the details shown on the table of human characteristics to determine your probable origin.

LIST OF FEATURES

1 *Skin colour*
- white
- olive
- brown
- black
- reddish

Note: disregard effects such as 'tanning' by examining the underside of the forearm.

2 *Hair colour*
- blonde/light brown
- dark brown
- black
- reddish

3 *Hair form*
- straight
- wavy
- kinked
- peppercorn

4 *Growth of body hair*
- heavy
- moderate
- slight

Note: some anticipation may be required.

5 *Body form*
- tall and slender
- tall and heavily built
- medium height medium build
- short and stocky
- short and slender
- extremely short and stocky

6 *Eye colour*
- dark brown to black
- grey, hazel, blue-grey etc.
- blue

7 *Eye fold*
- present
- absent

8 *Shape of nose*
- long, narrow
- medium length, medium width
- extremely broad
- hooked

9 *Head shape*
- long (width : length 75%)
- medium (width : length 75–80%)
- broad (width : length 80%)

10 *Shape of lips*
- thin
- medium
- very thick

11 *Blood type*
- A
- B
- AB
- O

Feature	Type
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	

CONCLUSION

My probable origin is ....

TABLE OF HUMAN CHARACTERISTICS

THE CAUCASOID GROUP

GENERAL FEATURES

- light skin (light olive brown, white, rubby)
- hair—medium to fine wavy to straight fairly abundant facial and body hair
- lips—medium to thin
- chin—moderately pronounced

SUBDIVISIONS

a *MEDITERRANEAN*

- head—long
- body form—slender
- skin—olive to light brown
- hair—black/brown straight to wavy
- eyes—dark brown
- distribution—Egypt, Arabia, Portugal, Spain, Southern Italy

b *NORDIC*

- head—long
- body form—tall, slender
- skin—ruddy to light
- hair—red/blonde/light brown straight/wavy/curly
- eyes—blue/blue-grey
- lips—thin
- nose—high narrow
- distribution—Sweden, Norway, England, Scotland, Northern Germany

c *ALPINE*

- head—broad
- body form—short
- skin—intermediate between a and b
- hair—intermediate between a and b
- eyes—intermediate between a and b
- face—round
- distribution—France, Southern Germany, Switzerland, Greece, Asia as far east as the Pamir mountains

d *ARMENOID*

blends of Mediterranean and Alpine (middle East)

- head—broad, high sloping forehead
- nose—hooked
- distribution—Turkey, Syria, Israel

e *DINARIC*

- head—round
- face—long
- nose—prominent
- distribution—Yugoslavia, Austrian Tyrols, West Asia, Asia Minor

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THE MONGOLOID GROUP

GENERAL FEATURES

- hair—straight black to brown
- eyes—brown
- body hair—sparse
- face—broad, projecting cheek bones
- nose—flat, medium broad
- eye fold—present

SUBDIVISIONS

a *CLASSIC*

- short, stocky
- yellowish skin
- distribution—China, Korea
- eye fold

b *ESKIMO*

- long head
- more prominent cheek bones
- reduced eye fold

c *AINUS*

- white skin
- black wavy hair
- distribution—islands of northern Japan
- no eye fold

d *COMPOSITE*

1 *Indonesians*

- probably hybrid of Mediterranean and Mongoloid
- distribution—South China, Indo-China, Thailand, Burma, Malaysia

2 *Amerindian*

- general mongoloid features but
- reduced eye fold
- higher cheek bones
- hawk nose
- reddish skin

e *VEDDOIDS* (Indians)

- slender
- dark skin
- long head, broad nose
- wavy hair, black
- moderate body hair
- Mediterranean stature

THE NEGROID GROUP

GENERAL FEATURES

- skin—dark brown to black
- hair—black woolly or frizzy hair
- nose—low and very broad
- lips—thick and puffy
- head—long
- body form—tall, slender
- blood—predominantly type O

SUBGROUPS

a *NEGRITE* (pygmies)

- height—average 145 cm
- round heads
- narrow shoulders
- pot bellies, short legs

b *OCEANIC NEGROIDS* (Polynesians and Melanesians)

- thinner lips
- less protrusive jaws
- lighter, less kinky hair

c *BUSHMEN* (South Africa)

- height—under 150 cm
- much lighter skin
- hair—very characteristic peppercorn

d *HOTTENTOTS*

- resemble c but taller

THE AUSTRALOID GROUP

AUSTRALIAN ABORIGINE

- chocolate to black skin
- brown to black eyes
- protruding jaws
- moderate body hair
- broad nose

EA 6–7 to EA 6–9 Comment for the student

No doubt you can see the difficulty of organizing investigations which are really practical in nature when one is investigating recent human evolution. Because of this difficulty, these exercises are *library centred*.

We suggest you now read activities EA6–7, EA6–8 and EA6–9, and select the one which most interests you. It would be far better to make one thorough study of this type than several sketchy efforts.

However, if there are a number of people in your class group, you should organize yourselves so that each activity is undertaken by some people and that opportunity is given for an integration seminar in which you will be able to share the ideas and knowledge you have gathered.

To help you make your selection the three library-centred enquiries are listed below.

EA6–7

Construct a time-line showing the steps of human cultural evolution. Draw a diagram showing when important changes occurred and write brief notes about them.

EA6–8

Survey major aspects of cultural change in Aboriginal prehistory. Why was there very little change?

EA6–9

Compare the frequencies of ABO blood types throughout the world. What theories have been put forward to account for the differences between regions of the world?

PROCESS OBJECTIVES

By the end of this activity you should be able to:

1 carry out research activities on different aspects of human evolution

2 organize groups to share information and prepare a seminar.

- Project. Time line for the future.

Note: A project for a teachers' workshop.

(Source: Kinghorn, Jon R. Schools Improvement Through Global Education a Step-by-Step Guide for Conducting a "Consensus and Diversity" Workshop in Global Education. Dayton Ohio: Charles F. Kettering Foundation 1979 pp 22-23.)

Activity 2: Time Line for the Future (60 Minutes)

WORKSHOP LEADER: "Most of us find it difficult to imagine future events, trends, lifestyles, conditions, or discoveries. In fact, the implications of an event often escape us. Now you are asked to look forty years ahead. What do you see? What global events may occur? Will we really run out of fossil fuel? How will our lifestyles be altered? What new discoveries might be awaiting us? The tendency is to think that things will not be much different. Perhaps not, but perhaps the pace of change will accelerate. Will there be changing value patterns? What world-wide events will affect us?

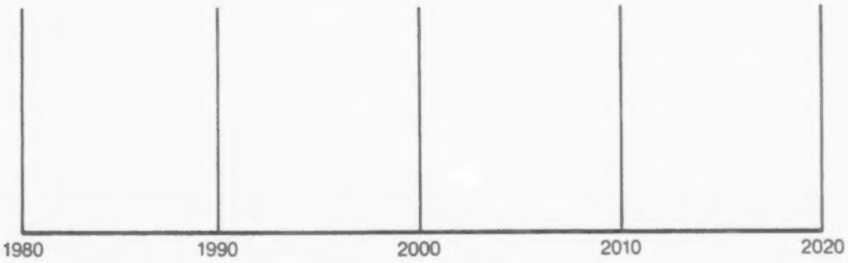
Everyone will have five to ten minutes to fill out the time line for the future. Then each of you will share your future time line with your group."

Participants remain grouped as in Activity 1. See Figure 4 for a sample time line. Following the sharing each small group will consolidate ideas and projections and develop a time line for display. They also will prepare a summary of their group's thoughts.

The workshop leader should process this activity with the total group. Ask each group to share some of the major events it listed on the world time line and the difficulty, if any, they had in thinking about the future. Point out that most have difficulty even thinking in a future mode. Also emphasize that most students will be very much a part of the next forty years. Assuming today's structure (perhaps a very faulty assumption), the students will not have reached retirement. What knowledge, skills, and attitudes do students need to help them experience happy, productive lives? What kinds of school programs do we need? What should be happening in the school? Should all teachers be responsible? All departments, all disciplines?

There will be profound changes during the next forty years. Can we stay open to change in our present school programs? As our global perspective develops, can we comfortably modify our programs to be more effective?

Figure 4: Time Line for the Future



. Project. Discussion questions on global issues.

(Source: Suggestion by author)

There are many global scientific issues which affect all people of the world. Some of these are listed below:

- overfishing in the oceans of the world
- the possibility of maintaining the Antarctic Continent as a wilderness area
- the torching of rainforests

- pollution problems such as acid rain
- the need for alternative forms of energy
- the need for international cooperative research into matters such as weather, communications or the promotion of world health (choose one of these or another of your own choice).

Divide the class into six groups. Each group should undertake library research into one of the above. Write a report of your library study under the following headings.

(a) What are the main world concerns in regard to the issue you have chosen for study?

(b) What contributions could biologists make to solving these global problems or meeting the world needs in the area of your choice?

(c) If you could advise an international agency such as the United Nations on what world-wide programmes should be organized over the next ten years in the area of your choice what would you suggest?

- Test Questions

(Source: Suggestions by author)

1. "Humankind today consists of only one biological species and yet we are highly diverse in regard to languages, religious beliefs and life styles."

   Discuss the relative roles of biological evolution and cultural evolution in determining the present characteristics of humankind as they are expressed throughout the world.
   [Five pages]

2. Write ten lines on the work of each of the following international organizations in the area of biology and its applications.

   (a) United Nations Education, Scientific and Cultural Organization (Unesco)
   (b) Food and Agriculture Organization (FAO)
   (c) The World Health Organization (WHO)
   (d) The United Nations Environment Programme (UNEP)
   (e) The World Bank
   (f) The International Council of Scientific Unions (ICSU)

3. (a) Draw up a table listing some points of difference and similarity in the ecosystems of planet Earth (i) just before the evolutionary emergence of humankind as a distinct species and (ii) at the present time.
   [Two pages]

(b) Which characteristics of the human species have enabled us to engineer planet Earth to an extent not possible by other species?
[Two pages]

(c) There are aspects of humankind's impact on the natural ecosystems of the planet which may need to be regulated and controlled through international cooperation. List some examples.
[One page]

4. Write a speculative essay of what the future may be like for humankind by the year 2500. Write under the following headings:

(a) World population
(b) Transport and communications
(c) Health
(d) The role of science in promoting human welfare
(e) War or peace

Do you think that over the next 500 years the peoples of the world will be more tolerant of each other and will have learnt to cooperate or will there still be major conflicts, disagreements and struggles for power and resources? Justify your answer.
[Six pages]

5. "The world is now too complex and too crowded for peoples of various countries to live in isolation from the rest of the world. We are all interdependent."
Identify and briefly discuss some examples of this interdependence in areas relating to biology or to the applications of biology.
[Five pages]

8.13 The Quality of Life

i) Rationale

The Unesco Principal Regional Office for Asia and the Pacific Bangkok has suggested that programmes focusing on "quality of life" should aim to equip the community at large "with that essential social knowledge, attitudes, values and skills about problems and issues affecting society as a whole so as to improve the life styles and standards of all citizens....Issues such as parenting, population education, drugs, citizenship, social and cultural awareness and leadership should be addressed by these types of programmes" (23). Other educators have given broader definitions (24) but all agree that quality of life programmes should be concerned with fostering the general wellbeing of humankind.

The well known American biology educator Paul Hurd stresses that school biology should focus sharply on issues relating to the quality of life. He comments as follows (25).

> ...a biology program for improving the quality of life entails a new synthesis of subject matter that encompasses the interactions and interrelationships of science, technology, society, and human values. The goals of the program would be defined in terms of human adaptive capacities essential for living in a world of change and to direct change. The context of the curriculum is science/social and the orientation is toward the future. What is sought is an education in biology for social participation and for co-operative efforts in interpreting and responding to biosocial problems and issues that can influence the quality of life.

Professor Hurd's philosophy is reflected throughout this book. In Chapters 6, 7 and 8 many social issues relevant to the concept of the quality of life have been considered individually. This present section deals largely with the concept as a whole. If biology at school can and should contribute to improving the quality of life then the concept should be treated within the school biology curriculum in its own right. As in so many other areas of a socially oriented biology programme the "connections" between the science and the social constant (in this case quality of life) will not occur unless both the science and the social construct are explained and the links made overt. It is not sufficient to simply hope that if the appropriate biology is taught some diffusion process will occur and standards of living will be upgraded.

Like the other areas of social concern discussed in this chapter the idea of biology contributing to improved quality of life is a future oriented concept. School programmes focusing on this issue should aim at preparing students to be future participants in the reconstruction and development of society so as to ensure improved life styles for all. Therefore the curriculum should review biology-based social activities and programmes which have the overt aim of improving the quality of life.

As in other areas reviewed in this part of the book, stress should be placed on the development of analytical and problem-solving skills, critical thinking, values clarification and the techniques of forward planning. Once again a case study approach is advocated. Students should also understand the complex social forces which interact to determine the standards of living of any community and use force-field analysis and similar planning techniques - that is to identify factors involved in particular cases, to work out how to enhance positive influences and to minimize inhibiting effects of negative influences.

The main point about dealing with the quality of life within a school biology programme, however, is that it should be dealt with overtly and directly as a named topic and not indirectly in the hope that the mere build-up of biological understanding at school will somehow affect a significant qualitative change in society as a whole. It will not.

ii) Examples of Content

Example 8.50: The meaning of "quality" in the term "quality of life"

School System: -
Approach: Background information for teachers. The results of an international survey of the opinions of 330 biology educators from five countries.
Source: Atchia, Michael "Biology and the Quality of Life" in Meyer, G. Rex (Ed) Selected Issues in Biological Education. Hamburg: Lit for IUBS-CBE 1990 pp 41-53.

Table 1: Elements considered important for a high quality of life, in descending order of importance.

REF NO.	ELEMENTS CONSIDERED AS VERY IMPORTANT	INDICATED BY 40 TO 60% OF RESPONDENTS
1	Access to, availability of, possession of, GOOD EDUCATION	60%
2	Good, pleasant, health ENVIRONMENT (also aesthetically pleasant, quiet, green, uncrowded, well-organised environment)	59%
3	GOOD HEALTH, access to good (free) health services	53%
4	GOOD RELATIONSHIP with others GOOD SOCIAL LIFE, friendship	50%
5	MONEY (Money as a means of improving ones 'standard of living')	49%
6	GOOD JOB, DECENT WORKING CONDITIONS, SATISFYING WORK	40%

REF NO.	ELEMENTS CONSIDERED AS IMPORTANT	INDICATED BY 18 TO 30% OF RESPONDENTS
7	LOVE and affection LOVE and harmony LOVE and happiness	27%
8	Possession of, development of, MORAL and SPIRITUAL VALUES Having a religion (3%) Spiritual fulfillment	25%
9	GOOD FAMILY-LIFE	24%
10	AMENITIES for living, for a comfortable life (own house, clothes, car, 'comfort', space etc.)	22%

REF NO.	ELEMENTS CONSIDERED AS IMPORTANT	INDICATED BY 18 TO 30% OF RESPONDENTS
11	FOOD (Adequate supply of, good food, wholesome food)	21.5%
12	PLAY Leisure time, entertainment, cultural life, sporting facilities, recreation Access to national parks, beauty spots and green spaces (Australia only, 2%)	21%
13	FREEDOM (of action, movement, expression) Political freedom, independence Freedom to travel overseas 'Recognition of my basic human rights'	19.5%
14	PEACE (within oneself), peace of mind Periods of solitude (1%)	19%
15	PERSONAL QUALITIES such as flexibility, objectivity of out-look, self-discipline, self-reliance (Zimbabwe only: 3%), ability to communicate with others, wisdom. Nice features and high social status (Kuwait only: 1.2%)	18%

REF NO.	ELEMENTS CONSIDERED OF LESSER IMPORTANCE	INDICATED BY LESS THAN 10% OF RESPONDENTS
16	PEACE (in locality, country, world) Absence of threat of war, of nuclear war	9.5%
17	Achievement of PERSONAL AIMS Personal development, success	8.5%
18	KNOWLEDGE (per se)	8%
19	JUSTICE, equality	6.5%
20	Good, stable GOVERNMENT	5%

REF NO.	ELEMENTS CONSIDERED OF LESSER IMPORTANCE	INDICATED BY LESS THAN 10% OF RESPONDENTS
21	SECURITY	3%
22	Possibility of exercising one's CREATIVE ABILITIES	2%
23	SIMPLE LIVING (West-Germany only)	1.5%
24	Adequate provision (of health care and social services) for the aged	1%
25	Music	1%*

* Entries adding up to less than 1% have not been recorded here.

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Example 8.51: Issues in "quality of life" studies

School System: -
Approach: *Background reading for teachers on the meaning of the term "quality of life" including an account of its scope and of relevant indicators*
Source: *Cheong, Siew Young "Biology and the Quality of Life" in Unesco: New Trends in Biology Teaching Volume V. Paris: Unesco 1987 pp 17-29.*

MEANING OF QUALITY OF LIFE

If teaching is to contribute to the improvement of the quality of life, then it is necessary for us to consider what we mean by 'quality of life' and what its concerns are. Despite the progress already made in the improvement of living standards in many parts of the world through the application of science and technology, a large number of people in the developing countries are still living in very deprived conditions. On the global level, it has been estimated that nearly 750 million people (out of a world total of about 4,453 million in 1980) which was approximately 33 per cent of the population of the developing countries (excluding China) are living in poverty, especially in the rural areas of South Asia and Africa South of the Sahara (The World Bank, 1981). World Health Organization (WHO) statistics show that hundreds of millions of children and adults in the developing countries suffer from malnutrition. Infections and parasitic diseases constitute a major source of disability and mortality in the developing countries of the tropics.

In addition, poliomyelitis, diphtheria and measles are also prevalent, and fewer than 10 per cent of the 80 million children born annually in the developing countries are being immunized against them. The infant and childhood mortality rates are generally high. In some Third World countries over 100 per 1,000 infants die during the first year, compared with about 10 in most industrialized nations. The health care delivery system is also poor in developing countries: for each 100,000 people there are about 200 health workers compared with about 1,000 in the industrialized countries. In the developing world, the differential in health conditions and the provision of health facilities between urban and rural areas is very striking, resulting in low health standards for the rural poor.

The high rate of population growth in the developing countries has strained, and will continue to strain, the existing levels of ill health, poverty and illiteracy. Growing at a rate of about 2 per cent, the population of the less developed regions (3,669 million in 1985) is estimated to reach about 4,851 million people (79 per cent of the world population) by the year 2000 compared with about 1,275 million people in the more developed regions (United Nations, 1985). This will certainly have implications for the supply of life's amenities including food, housing, water, sanitation, health, medical care and education.

Education is recognized to be the most important key to socio-economic development. But the adult literacy rate in most developing countries, though rapidly increasing, is low. It has been reported that some 900 million adults in developing countries can neither read nor write, and in the less developed areas a large majority of children do not complete primary school. Illiteracy hinders people's understanding of many personal and social problems and thus impedes the development of appropriate attitudes and values needed for modernization. Superstitious beliefs and traditional, often scientifically unsound, treatment of ailments still characterize the life patterns of the poor.

Socio-economic problems of developing countries are not only those that have arisen as a result of poverty or lack of development. The activities of development - technological industrialization, exploitation of natural resources and high-level economic development - have also contributed their share of problems that have an impact on individuals and society. Problems such as pollution, destruction of the natural heritage, soil erosion and degradation of environmental quality are prevalent in many countries undergoing rapid economic growth. In addition, the rise of affluence in many developing countries has led to problems that are similar to those experienced by advanced countries, including malnutrition, drug dependency, alcoholism, degraded moral values, sexually transmitted diseases, excessive consumption of energy, lack of contentment and lack of a human approach to problems in life.

It is generally recognized that quality of life is a concept that allows for many definitions, and that there is no widely accepted index for its measurement. The difficulty in obtaining consensus of meaning is largely due to the fact that the notion of 'quality' is not amenable to precise definition, nor to easy measurement. However, perceptions about quality of life and its pursuit can be derived from two related perspectives - national and individual. From the national perspective, the standard-of-living criterion is normally used by most governments to assess the level of well-being of society and the progress society is making towards quality-of-life goals. From the personal perspective, quality of life can be interpreted to mean the degree of excellence in one's lifestyle, generally a subjective judgement. People's perception of their own well being or lack of well being ultimately defines the quality of their lives (Andrews and Withey, 1976).

In summarizing various definitions, (Cheong, 1983) considers the following elements important for quality of life:

Biological variable. The satisfaction of basic biological needs is of fundamental importance both for survival and for the quality of life. The availability of nutritious food, clean air, unpolluted water, a life relatively healthy and free from sickness, adequate housing and sanitation are also essential.

Economic variable. From the individual point of view, two factors are important: (a) an opportunity to work to earn an adequate income and to achieve self-actualization; and (b) money to purchase modern material goods. From the societal viewpoint, quality of life is a function of economic capabilities and depends on an equitable distribution of the society's economic opportunities among the people. In developing societies, it would imply, for example, a better earning capacity for people living in rural areas. Employment opportunities and an adequate income for all would be the ultimate goal.

Social variable. The freedom to make choices and decisions and to participate in the affairs of society is an important dimension of democratic life. Other factors are lack of discrimination based on sex, place of residence, religion, race, or physical or mental handicap; access to social services and cultural activities; and law and order.

Environmental variable. The environment consists of both the natural and the human environments. The natural environment includes natural resources such as land, air, water, fauna and flora, mineral and oil deposits. In general, the quality of life is severely reduced if the natural environment is badly managed. The human environment comprises the populations of countries and the socialization process. In some cases an increase in the population can contribute to economic progress, but in other instances a large population is a liability to the achievement of a desirable standard of living for the people.

Humanistic variable. The psychological and affective aspects of human life are extremely important. Human feelings and emotions, in particular happiness, inner harmony, spiritual fulfilment, peace of mind and general contentment, are critical to attaining mental well-being and hence increasing the quality of one's life.

INDICATORS OF THE QUALITY OF LIFE

Various indicators are needed to measure the well-being of society. Economists have used economic indicators such as the gross domestic product, which do not provide an adequate measure of non-economic activities. In the past ten years attempts have been made to develop social indicators that might provide a better measure of well-being. Such indicators include overall satisfaction, health, housing, personal safety, leisure time, arts and humanities, education, working life, prospects for the improvement of well-being, and civic concern (Panel on the Quality of American Life, 1980).

In most developing countries, the trend has been to use a combination of social and economic indicators by identifying quantifiable indicators for concerns such as food, health and environmental quality. For example, infant mortality rate is one socio-economic indicator for the social concern of health; nutritional status for the concern of food; and pollution for the concern of environmental quality.

The major concerns of society, obviously, vary from culture to culture, and even within each country from region to region. Our purpose here is not to arrive at a list of social concerns that are universally acceptable but rather to suggest that society's concerns *vis-à-vis* quality of life can provide us with some indications as to how biological education might be re-oriented to make it more relevant to the quality of life.

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Panel on the Quality of American Life. President's Commission for a National Agenda for the Eighties. The Quality of American Life in the Eighties. Washington DC: Department of Health and Human Services 1980

United Nations World Population Prospects: Estimates and Projections as Assessed in 1982 (Population Studies No 86). New York: The United Nations 1985

The World Bank World Development Report 1981. Washington DC: The World Bank 1981 pp 17-18

iii) Examples of Project and Test Questions

(The following are suggestions by the author.)

. Project. Form discussion groups to consider the question "What is the meaning of the term 'quality of life'?" By sharing reports of the discussion groups draw up a list of "indicators" of quality in the life styles of citizens in your community - ie. a list of things people need or strive to obtain to have a good standard of living.
Discuss and write brief reports on the following questions:

(a) Which aspects of quality of life are biological in nature or which have some relationship to biology?

(b) How could biological ideas and techniques be applied in your community to improve the overall quality of life of most citizens?

. Project. Discuss the following quotation in small groups and then answer the questions which follow.
"In some countries most people have a 'poor' quality of life and in others most have a 'good' quality of life."

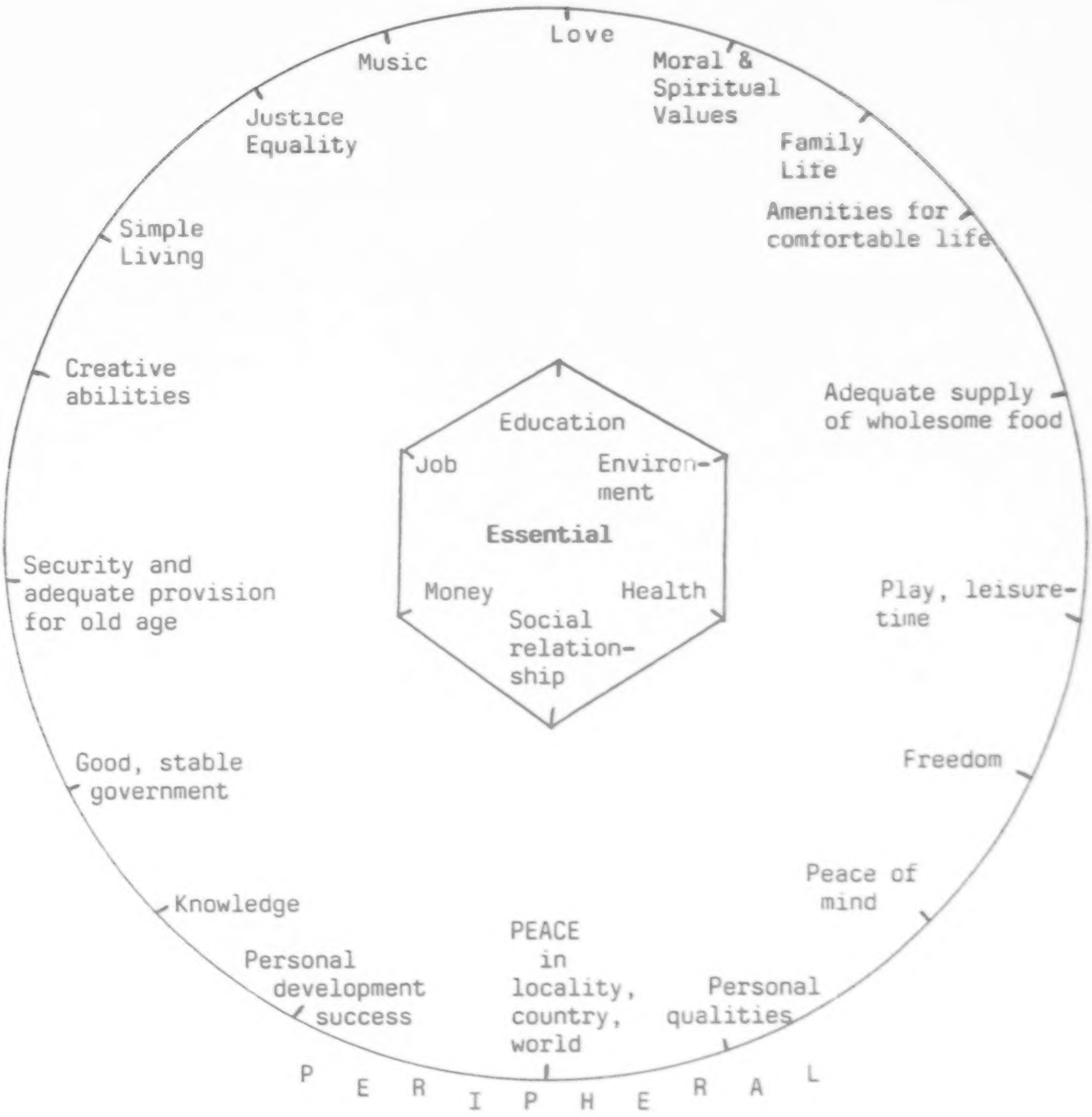
(a) What do the words "good" and "poor" mean in the above quotation?

(b) With the help of library research make a list of five countries which could be said to have a rather poor quality of life for most citizens and five in which most citizens have a good quality of life.

(c) Discuss which economic, social and other factors could be responsible for the differences between the two groups of countries.

(d) How could biologists, in their role as scientists, assist in improving the quality of life in those countries which you classified as having "poor" standards?

. Project. A model of the concept "quality of life". (A project for senior students).
Form discussion groups and consider the following model of the concept "quality of life". Prepared by Dr. Atchia of UNEP.


Love
Music
Moral & Spiritual Values
Justice Equality
Family Life
Amenities for comfortable life
Simple Living
Creative abilities
Adequate supply of wholesome food
Education
Job
Environment
Essential
Security and adequate provision for old age
Money
Health
Social relationship
Play, leisure-time
Good, stable government
Freedom
Peace of mind
Knowledge
PEACE in locality, country, world
Personal development success
Personal qualities
PERIPHERAL

Discuss the following questions:

(a) On which grounds do you think Dr. Atchia has grouped some aspects as "essential" and some as "peripheral"?

(b) For each of the six essential aspects of the quality of life shown in the diagram consider how the ideas and processes of biology could be applied to improve standards.

(c) The aspects "freedom", "creative abilities", "good stable government" and "simple living" are shown as peripheral elements in the model. What links, if any, are there between these and the central "essential" elements? How could the application of the principles of biology strengthen some of these links?

Source of diagram: Atchia, Michael The Concept of "Quality of Life" a Model. Paper presented to the annual meeting of the Education Commission of the International Union of Biological Sciences Bangalore India August 1985.

. Test Questions

1. Assume that a particular country is preparing a five year plan to improve the quality of life of its citizens.

   (a) List five social areas which the plan could cover.
   (b) For each area you have named write about five lines on how biologists could help improve the quality of life.

2. Is it possible to "measure" the quality of life? Explain. [Write an essay of about five pages]

3. What contributions can biology make to improving the quality of life for most citizens?
[Write five pages]

4. How can the developed world help underdeveloped countries improve the quality of life of their citizens?
[Write five pages]

5. The term "quality of life" usually refers to standards of living of humankind.

   (a) Could the term be applied to the lives of non-human species? Explain your point of view.
   [Three pages]

   (b) What responsibilities do we have as a species towards qualitative aspects of the lives of other species?
   [Two pages]

Notes and References

Note: Sources of exemplar materials are cited in the text and are not included in this list.

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(22) In part derived from Becker, James M. Ibid pp 46-47

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Cheong, Siew Yeong "Biology Teaching and the Quality of Life" in Unesco: New Trends in Biology Teaching Volume V. Paris: Unesco 1987 pp 17-29
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(25) Hurd, Paul De Hart "The Teaching of Biology: A Possible Future" *The BSCS Journal* Vol 1 No 4 1978

PART III

ASSESSMENT ISSUES

Introduction to Part III

There is a vast literature on the principles, procedures and techniques for assessing student achievement in school biology. Unesco has produced several useful reports in this area and groups such as the Biological Sciences Curriculum Study (BSCS), the National Science Teachers Association and the Educational Testing Service in the United States; the Nuffield Biology Teaching Project and the Science Masters Association in Britain, and the National Science Curriculum Materials Project (NSCM) in Australia, have published monographs, guides for teachers and volumes of test items. Part III of this volume, therefore, does not aim to review basic matters such as writing test items, test construction issues and testing procedure as such. Its aim is to show how assessment principles and procedures should be applied within a programme focusing on general education and stressing social relevance.

Any assessment system must of course be concerned with measuring the achievement of the objectives of particular programmes. In a socially oriented programme these objectives must make the applications of biology overt, especially in regard to their role in social issues. The content examples of test items, therefore, must have a societal focus and should not deal only with the classical subject matter of biology.

Further, since a socially oriented programme of school biology aims to foster such skills as problem solving, critical thinking, interpretation, values clarification and conflict resolution, the types of test items must be capable of measuring achievement in these areas. They must, therefore, be interpretative, thought provoking and intellectually challenging and should not merely check on routine memory work. In the case of objective tests only those types which can assess interpretative, attitudinal and relevant practical skills should be used - multiple choice formats for example are especially powerful in that regard. Objective items such as completion tests, true-false statements and matching types may have some place but should emphasise interpretation rather than recall of knowledge. Short answer formats are also useful - writing a few lines of explanation or comment in structured answer spaces; but longer answer formats such as essays, evaluative reports, plans, and creative writing (poems, stories etc.) are especially important in checking on the achievement of socially relevant objectives.

Socially relevant courses, like any other, should be assessed across the three domains of cognition; the affective domain and the domain of psychomotor skills, but in all cases the emphasis should be on social issues. For example it would be important when checking on the ability to apply knowledge, not to test merely for application from one area of biology to another, but application from biology to some critical societal area.

As a socially relevant biology programme involves a gradual build-up in knowledge, understanding, interests, positive social attitudes and both scientific and social practical skills, terminal testing alone (and of course at end of year) is inadequate and should be supplemented by some form of continuous assessment. This in turn should reflect the gradual unfolding of the fabric of the course as a whole through the cumulative achievement of the socially relevant objectives.

A socially focused approach has especially important implications for public examinations. Classical practical test items such as performing chemical tests on food or dissecting a rabbit have little or no place. Written tests should reflect the social ambience of the course as a whole and the stimulus material for most items should almost always present a social problem first and its biological components second, rather than the other way around as in more traditional programmes.

This part of the volume considers only broad issues and principles. Some examples of test items are included but readers are also referred to the wide range of test questions given in Part II.

Chapter 9

CONTINUOUS ASSESSMENT

9.1 Introduction

By assessment is generally meant "the process of gathering data and organizing it into an interpretable form so that it provides a basis for decision making" (1). Generally a distinction is made between terminal or summative assessment as against formative or cumulative assessment which is sometimes referred to as continuous assessment. Terminal assessment is made at the end of a course of study or of a major part of a course. Continuous assessment occurs at defined intervals throughout a course, usually at the end of specified units of work.

Assessment has several functions. Most teachers see it as an exercise in grading, that is determination of whether or not a student has attained a satisfactory standard in a unit of work or in a course as a whole and is ready or not to move on to new work or obtain some level of award. Grades can be expressed normatively, that is in comparison to standards achieved by others, or they can be criterion referenced, that is expressed in terms of objectives achieved or in terms of a predetermined standard of performance.

Assessment, however, has other important functions. Probably the most significant of these is to contribute to teaching and learning by the provision of feedback to students on progress towards achievement of acquired objectives and through the diagnosis of strengths and weaknesses. Another important function is to foster communication between teacher and learner. Because students tend to organize their study around the demands of assignments and other assessment requirements, assessment helps them understand the objectives of the course and the standards expected. Evaluation is another very important function of assessment. Assessment can provide a student with useful information on his or her level of attainment and can give the teacher insight into his or her teaching effectiveness. It can also provide evaluative information on curriculum issues such as methods, resources, appropriateness of objectives and on the overall effectiveness of a course. Assessment also has an important predictive role. It indicates if a student is ready to move on to another unit of work; to proceed to another level; to undertake in-depth studies or remedial work; to select optional alternatives; to proceed to alternative courses or to enter a profession or trade.

In a socially oriented programme of school biology continuous assessment is especially recommended because of the complexity of the objectives and because of the varied methods of teaching involved in achieving the objectives. The assessment procedures involved should be wide ranging and not restricted to formal cognitive tests and examinations. It is important, too, that the grading components of an assessment programme be clearly separated from components with other functions such as feedback, curriculum evaluation or predictive counselling. Both teachers and students should be very clear about the purpose and function of each component.

9.2 Principles and Procedures

(a) Purpose of Assessment

Within a socially oriented programme of school biology it is important to utilize assessment procedures which function not only for grading but also for the purposes of teaching (feedback), communication, evaluation and prediction.

i) Grading. In a socially oriented approach the relative weighting of those elements of the assessment programme is especially important. While cognitive, affective and psychomotor aspects of achievement should all be included it is the affective area which is of special significance. In particular, attitudes, interests, values and the analysis and resolution of conflict are especially important in dealing with social issues. This poses something of a problem for teachers because objective techniques for measuring achievement in these areas are somewhat more complex than for the cognitive or psychomotor domains. In the cognitive area it is the applied problem solving skills, including critical thinking and evaluation which are especially important. In the psychomotor area practical skills of the laboratory remain significant but should be supplemented by more socially oriented skills such as social survey methods, interview techniques and so on.

A key aspect of grading within a socially oriented biology programme is the need to clearly define those aspects of the course which are essential for determining student progress. These aspects will be somewhat different from those within a purely classical biology course and should focus on assessing the ability of learners to apply their science to understanding societal issues and concerns.

Grading should be based on much more than the formal results of tests and examinations. In particular assignment and project work should contribute as should practical activities, general classroom attitudes and behaviours and social variables such as communication skills, leadership qualities and general creativity. In fact it is these broader aspects which have the greatest significance in socially oriented programmes.

ii) Teaching - Especially Feedback. Of course the grading elements of an assessment programme do provide important feedback to the learners. But there should be many other opportunities provided to help students appreciate their standing in regard to the objectives of the programme. In particular self-evaluative checklists are very important in helping develop a positive self image and for appreciating standing within a programme. These, however, will only be answered openly and frankly if students are aware that answers are not being used for grading purposes. Self-scoring inventories are very important in checking on whether transfer is occurring from the science classroom to society as a whole. Qualitative feedback on assignment work, project reports, case studies and so on should be given separately from a grade and should focus on the ability of the learners to perceive the broad social implications of the various learning activities.

iii) Communication. Specific opportunities should be built in to an assessment programme to help students focus more sharply on the objectives of the course and to appreciate more clearly the standards required. Preferably some of these should not be used to accumulate evidence for a grade. If they are introduced purely to clarify objectives and to help students understand what is expected they will be useful for establishing guidelines for study and will not be approached as competitively as they would be otherwise. In socially oriented biology courses the links between the science and the social issues must be made very clear. Frequently a unit of work may start with a social problem rather than with a biological concept. Unless the objectives of such units are clearly understood transfer will not occur. Specific assessment activities should be introduced from time-to-time to check on this aspect.

iv) Evaluation. From time to time students should be provided with qualitative evaluations of their attributes across a broad range of variables. Some of the data provided in such "profile" reports could come from cumulative records and some from especially devised non-grading assessment procedures. In addition teachers should build in assessment devices which check on aspects of course design, resources, classroom procedures and so on. Since socially oriented biology programmes as advocated in this volume are at a very early experimental stage of development, assessment designed to provide such evaluative information is vital to fine tune the programmes and to improve all aspects of design and presentation.

v) Prediction. Socially oriented programmes are especially enriched if they contain specific units dealing with a range of social issues. Some of these may be presented as alternatives. It may be useful to build in diagnostic pre-tests to check if students need additional information or skills before beginning new units of work or to help them choose between instructional options. Such diagnostic tests should not be part of the grading programme but should be given to help students make decisions and to guide them in preparing for a further stage in the programme.

(b) Components

Because of the various functions of assessment outlined above any programme of continuous assessment should include a wide range of assessment procedures. Also because all types of assessment procedure (achievement tasks, attitude tests, personality inventories and so on) have technical limitations it is important to seek several sources of evidence on any one aspect. This is particularly important in a socially oriented programme of biology because the range of objectives to be monitored is considerably broader than in the case of more conventional programmes.

The emphasis given in the assessment procedures also needs to change so that social applications are highlighted. The following table lists some possible components of an assessment programme and suggests some differences between their use within a conventional and a socially oriented biology programme.

Some Components of a Continuous Assessment Programme and their Roles in Conventional and Socially Oriented Biology

Component	Role in Conventional Biology	Role in Socially Oriented Biology
1. Cognitive Achievement Test	Assess skills in comprehension, application, analysis, synthesis and evaluation within and between concepts within the structure of biology. In particular transfer from one area of biology to another. Example Application of the principles of genetics in explaining how evolution works.	Assess skills in comprehension, application, analysis, synthesis and evaluation of biological concepts as they relate to social issues. Example Application of concepts of genetics and reproductive physiology in reviewing an ethical dilemma concerning abortion or experiments with human embryos.
2. Affective Achievement Test	Test willingness to receive, respond to and value information and procedures in experimental biology. Example Valuing the power and significance of the processes of science in biology.	Test willingness to receive, respond to and value those aspects of biological knowledge and skill needed to review social issues or resolve social conflicts. Example Appreciating the value of certain areas of

Component	Role in Conventional Biology	Role in Socially Oriented Biology
2. Cont.		biological knowledge in analysing the pros and cons of an environmental issue such as building of an urban freeway.
3. Psychomotor Achievement Test	Test ability to undertake practical activities in the biology laboratory and the field at defined levels of skill - imitation, manipulation, precision, articulation and naturalization with the aim of improving skill in biological techniques. Example Follow detailed instructions to dissect the digestive system of a rabbit with sufficient precision to display all parts neatly and without damage.	Test ability to undertake practical activities in the biology laboratory and the field at defined levels of skill - imitation, manipulation, precision, articulation and naturalization, with the aim of providing evidence necessary for the review of a social issue. Example Chemical and biological tests and interview surveys to assess the nature and impact of chemical pollution in a village water supply.
4. Practical Output	Check on quality of a practical product/object illustrating some aspect of biology. Example Scope and technical quality of a mounted herbarium collection.	Check on quality of a practical product/object illustrating the application of biology to the review of social issues. Example Scope and technical quality of a partfolio of photographs illustrating positive and negative aspects of a specific urban environment.

Component	Role in Conventional Biology	Role in Socially Oriented Biology
5. Project and Case Study Report	Test of ability to write coherent and insightful reports on phenomena or events in biology. Example Report of a series of experiments to study the effect of various nutrients on the growth of a species of flowering plant.	Test of ability to write coherent and insightful reports on social problems or issues with a basis in biology. Example Report of a social survey of attitudes towards proposals to drain a local swampland for housing development.
6. Formal Essay	Test of ability to write structured and unstructured essays on purely biological topics. Example An essay on the evidences for evolution.	Test of ability to write structured and unstructures essays on the applications and roles of biology and biology-related concepts in matters of social concern. Example An essay on the role of biology in national development.
7. Creative Writing	Test of ability to write literary essays, poems or plays on some aspect of biology. Example Written interview between the student and Watson and Crick about the discovery of the structure of DNA.	Test of ability to write literary essays, poems or plays on some aspect of the link between biology and society. Example Article for a popular magazine on the problem of misuse of illegal drugs in society.
8. Personality Inventory Questionnaire and Rating Scale	Rarely used in biology but when utilized usually aim to provide data for studies of behaviour and growth of	Important in socially oriented programmes to check on how students clarify values and on attitudes such as commitment to social

Component	Role in Conventional Biology	Role in Socially Oriented Biology
8. Cont.	individuals. Example Tests of cognitive preference as part of a series of experiments on learning.	reconstruction, community well being and so on. Also important as a part of personal development studies. Example Attitude test to assess values in relation to introduction of a community health programme.
9. Sociometric Tests	Rarely used in classical biology but could be used to identify isolates, potential leaders and clusters for various activities such as discussion sessions, practical activities and field studies. Example Sociometric test to help in the formation of small groups to perform experiments on animal physiology.	Useful in socially oriented programmes for the formation of well led and compatible groups to perform socially sensitive activities such as writing group reports on controversial issues or conducting opinion surveys on matters of concern to the community. Example Sociometric test to identify team leaders and groups for a community survey of opinion on whether or not fluoride should be added to the local water supply.
10. Observation Techniques	Application of observation schedules to rate students on behaviours such as (i) attitude and skill in laboratory technique, (ii) participation in classroom activities and discussion.	Application of observation schedules to rate students on behaviours in social settings, eg. (i) performance in group discussions on socially sensitive issues, (ii) skill in interviewing fellow students on a socially sensitive issue.

Component	Role in Conventional Biology	Role in Socially Oriented Biology
10. Cont.	Example Observation rating schedule to check on ability of students to use a biological microscope.	Example Observation rating schedule to check on roles in a group discussion on the pros and cons of surrogate motherhood.
11. Oral Communication Tests	Test of skill in (i) listening and (ii) speaking during class activities or in discussion groups in areas of biology content. Example Assessment of student lecturette on "animals of the tundra".	Test of skill in (i) listening and (ii) speaking during class activities or in discussion groups in areas of social concern relevant to biology. Example Assessment of student lecturette on "the role of biologists in maintaining world peace".
12. Qualitative Self Reports	Descriptive reports of personal qualities of individual students freely written by the students in relation to activities in biology. Eg. roles in laboratory work or field studies. Example Descriptive report entitled "What I like best and what I like least in biology".	Descriptive reports of personal qualities of individual students freely written by the students about their roles in socially relevant biology. Example Descriptive report entitled "What I would like our biology class to do to help the local community".
13. Cumulative Records	A battery of assessment data collected over a period of time across a range of variables relevant to the subject matter of biology.	A battery of assessment data collected over a period of time across a range of variables relevant to the role of biology in society.

Component	Role in Conventional Biology	Role in Socially Oriented Biology
13. Cont.	Example Student achievement records on defined areas of biology such as taxonomy, ecology, physiology etc. Aim to check on readiness to progress to new work and for educational counselling.	Example Student achievement records on various activities linking biology with social issues eg. case study analysis; social problem solving; critical thinking about biologically relevant social issues. Aim to check on readiness to move to new work and for educational counselling.
14. Curriculum Evaluation Inventories	Collection of data on attitudes to and effectiveness of a classical biology curriculum - objectives, resources, methods etc. Example Checklist of attitudes to course objectives to assess student perceptions of their significance in biology	Collection of data on attitudes to and effectiveness of a socially oriented biology curriculum - objectives, resources, methods etc. Example Checklist of attitudes to course objectives to assess student perceptions of the role of biology in society.

(c) Programming

In programming an assessment programme for a socially oriented course in school biology particular care should be given to the relationships between the purely scientific content and the social issues. In addition the different functions of each element of the assessment programme must be made clear - in particular elements for grading should be set out separately from non-grading elements.

The timing of the various assessment procedures is critical. Well designed courses have clearly defined units of work and critical "nodes" where work is consolidated and reviewed. Assessment should occur just before or just after the various units and should also be associated with the developmental "nodes".

The following steps in procedure are suggested.

1. State the purpose, aims and general objectives of the course as a whole.

2. Prepare a table with the following headings. For each week of the course (numbered 1-n), complete columns (i) to (iv) based on a normal teaching sequence.

(i)	(ii)	(iii)	(iv)	(v)	(vi)
Week No.	Main Biological Concepts, Attitudes and Skills	Social Issues, Attitudes and Skills	Strategies and Types of Activities eg. small or large group work, surveys, laboratory experiments, workshops, etc.	Assessment Procedure for Grading	Assessment Procedure not for Grading (State purpose)

3. Determine the type of grading to be applied to the course as a whole (Grades A to F, Percentage Grade, Pass/Fail, Credit/No Credit, etc.)

4. Decide which aspects of the programme need to be assessed as part of a system of continuous assessment that will contribute to the final grade.

5. Devise appropriate methods of assessing and grading each of the particular aspects identified in step 4 - eg. essay, objective test, project, practical test, etc. Enter this information in column (v) opposite the relevant weeks. Be careful to distinguish between criterion referenced and norm referenced situations.

6. Decide at what points (by week) there should be some cumulative assessment (including terminal assessment) for the purposes of grading (that is assessment across more than one area of work). Determine methods of assessment and forms of grading for each and enter the information in column (v).

7. Review the overall course outline in columns (ii), (iii) and (iv) and the total scheme of assessment for grading in column (v). If too elaborate, simplify.

8. Determine the weightings (in terms of percentages) to be given to each aspect of the programme of continuous assess-

ment for grading (including any terminal assessment) and add this information to the relevant entries in column (v).

Criteria for weighting will vary from course to course, but in all cases should clearly relate to objectives and activities. Write out on a separate page each component of the assessment, its weighting and a statement justifying the weighting given.

9. Decide which aspects of the course should include formal assessment procedures for the purposes of:

   (a) giving students feedback on their progress

   (b) giving staff feedback for evaluating the course or the teaching

   (c) any other purpose apart from grading.

   Devise suitable forms of assessment for these purposes and enter this information in column (vi).

10. Check through the strategies and activities in column (iv) and ensure that sufficient opportunities have been included for the following types of assessment which should be included in column (vi):

    (a) assessment-based activities devised to enhance learning eg. programmed instruction, questioning, etc.

    (b) self-assessment activities by the students, eg. self-rating scales.

11. Develop and produce the various instruments (tests etc.) required for all aspects of the assessment programme.

12. Prepare and issue to students a clear statement of all aspects of the assessment programme.

The overall assessment programme should reflect the spirit of the course as a whole. Maximum weightings should be given to testing understanding attitudes and skills in interrelating the scientific and societal elements in the analysis of relevant social issues and concerns.

(d) Evaluation of the Assessment Programme

After the assessment programme has been designed (Sections 9.2 (b) and (c)) it should be carefully evaluated against a set of design criteria. The following inventory is provided as an example of how such an evaluation may be undertaken (2).

Criteria for Evaluating an Assessment Programme for a Socially Oriented Course of School Biology

Evaluate the effectiveness of the assessment programme by placing a tick (✓) in the appropriate column headed satisfactory or unsatisfactory against each of the following eighteen criteria.

	Criterion	Satisfactory	Unsatisfactory
1.	All aspects clearly relate to achievement of the socially oriented objectives of the course	....	....
2.	There is an effective system for providing students with information on strengths and weaknesses in relation to achievement of objectives	....	....
3.	Elements contributing to grading are clearly identifiable	....	....
4.	Weightings of all elements contributing to grading are clearly indicated	....	....
5.	Elements not to contribute to grading are identifiable and their purpose is clear	....	....
6.	Opportunities are provided for self evaluation by students	....	....
7.	There is an effective system for student and teacher to compare their assessments and discuss relative perceptions	....	....
8.	There is a sufficient variety of assessment procedures to maintain interest and strengthen reliability	....	....
9.	All aspects are sufficiently reliable for their purpose	....	....
10.	All aspects are sufficiently valid for their purpose	....	....
11.	The frequency of assessment is optimal for its purpose	....	....
12.	The "timing" of all elements of the assessment programme correlates with significance points of development in the course	....	....

13. The "amount" of assessment is optimal for the time available and for the work load of the students ....

14. All procedures for assessment encourage depth of achievement and minimize rote learning ....

15. All aspects of the assessment programme may be clearly communicated to students and staff ....

16. Wherever appropriate students have a choice of alternative forms of assessment consistent with the objectives ....

17. All procedures for assessment are consistent with the content, resources and methods of teaching are relevant to the relationships between biology and society ....

18. The overall assessment programme focuses on the relationship between the scientific and social components ....

As the approach advocated in this volume would be relatively new for most school systems, carefully designed comprehensive assessment programmes are especially significant. They should be developed with the double aim of (i) helping students learn and (ii) helping presenters and course designers determine weaknesses and strengths in the courses with the aim of improving quality and impact. Systematic evaluation of assessment programmes is very important to ensure that the most appropriate data are available for these purposes.

(e) Administration and Interpretation

Apart from the formal requirements of grading, the most important aspect of any assessment programme is the provision of feedback to the students on the one hand, and to teachers and course designers on the other. This means that the organization and display of assessment data for their various purposes is critical. Students should receive regular qualitative and quantitative reports across a wide range of variables. These reports, however, should highlight progress in relation to the central aims and objectives of the course as a whole - namely development of understanding, appreciation and skill in relating the science of biology to the needs of society.

Those aspects of the assessment programme contributing to the final grade need careful attention in regard to relative weighting and also to the usual technical requirements of reliability and validity. If a final grade or "mark" is to be derived then ideally the raw scores of the various individual components should be standardized before addition. If such statistical procedures are not possible then the various elements should be graded more or less to the same class mean and spread of marks before being added.

As a particular course proceeds it is critically important that the nature and purpose of all elements of the assessment programme be made clear to students. They should know what use will be made of the data and especially if any aspect of the assessment will or will not affect their grades or affect them in any other way. Only if these aspects are made clear will students be willing to participate openly. They need to be reassured that assessment is for their benefit and for the benefit of future generations of students as experience leads to improved course design.

9.3 Conclusion

In a programme of socially oriented biology assessment shifts from checking on a narrow range of factors relating only to the traditional content of the discipline. It gives emphasis to dimensions such as the social development of the students, communication skills and to problem solving, critical thinking and the analysis of values as they relate to the investigation of biology related social problems and issues.

Since the focus is more on the needs of the students themselves and of the society as a whole the technique of assessment also should be broader in scope than the usual written quizzes, essays and practical tests used within a more conventional biology course (3). In particular self rating scales, attitudes tests and values clarification instruments should be used as well as cognitive tests of knowledge and skill in handling the problems of the real world (4). A key emphasis should be to use assessment as a teaching device to ensure that transfer occurs between the principles, concepts and processes of biology to the day-to-day concerns of students as members of society.

Notes and References

(1) Meyer, G. Rex; Jenkins, Carole; and Chan, Evalina Developing a Program for the Assessment of Student Performance (Processes of Teaching and Learning Minicourse M22) Second Edition. Sydney: Macquarie University Continuing Education Program 1981.

(2) Based on Meyer, G. Rex et al. Ibid.

(3) For an excellent account of a broader approach to assessment see Doran, Rodney L. Basic Measurement and Evaluation of Science Instruction. Washington DC: National Science Teachers Association 1980.

(4) A useful range of item formats is provided in Mayer, William V. Assessment: A Practical Guide to Improving the Quality and Scope of Assessment Instruments (Science and Technology Education Document Series No 16). Paris: Unesco 1986.

Chapter 10

ASSESSING COGNITIVE ACHIEVEMENT

10.1 Introduction

In the assessment of cognitive achievement the mental skills identified by the American psychologist Benjamin Bloom and his colleagues (1) remain the central focus. These are the skills associated with the recall of knowledge, and of the comprehension application, analysis, synthesis and evaluation of knowledge. In conventional biology courses assessment focuses on the development of these skills within the framework of the discipline but in more socially oriented programmes the emphasis is on the links between biology and society. This shift in emphasis is not so much reflected in the forms of test items used but in the nature of problems posed in the type of stimulus material on which the test questions are based.

Since socially applied biology is mainly concerned with the more complex mental skills associated with critical thinking and problem solving, it is not surprising that categories of the cognitive domain given greater emphasis in these types of programmes are the higher order skills of application, analysis, synthesis and evaluation. Evaluation skills are especially significant in reviewing social issues and these should be given considerable weighting in any assessment programme for socially relevant biology. Multiple choice, short answer and extended answer (essay) question formats are more suitable to test achievement of higher order mental skills than simpler formats such as completion, matching or true/false types.

Cognitive skills especially relevant to science should of course be highlighted in any science course, irrespective of its degree of social focus. These more specific cognitive skills have been identified as the following (2).

Knowledge
Comprehension
Criticism and analysis
Creativity
Deduction and inference
Realism
Accuracy
Numeracy
Literacy (vocabulary)

Apart from these broad mental skills which are especially relevant to science there is a series of intellectual skills relevant to the processes of scientific inquiry. The American educator Leopold Klopfer has identified those process skills which should be assessed in any school science course. His list consists of the following (3).

- Observing and measuring
- Seeing a problem and seeking ways to solve it
- Interpreting data and formulating generalizations
- Building, testing and revising a theoretical model
- Applying scientific knowledge and methods

Again however, in programmes of socially relevant biology it is the societal content of these skills which should be of central concern. Similarly the familiar "processes" of science such as observation, measurement, hypothesis building, explanation and so on should be assessed in such a way that the transfer from the pure to the socially applied aspects of biology is emphasised.

As stressed in Chapter 9 the purpose of assessing cognitive achievement should be clear. If it is for comparative grading purposes then normative aspects should be emphasised but if it is to check on readiness to undertake new work then individual diagnostic or mastery approaches may be more appropriate. Cognitive data may also be required for the purposes of curriculum evaluation and if so the use of pre- and post-tests before and after defined units or activities could be especially useful.

10.2 Principles and Procedures

(a) Assessing General Mental Skills

Technical aspects of the assessment of general mental skills in a socially oriented biology programme are no different from those in a more conventional programme. That is, the types and structure of the questions, test construction methods, item analysis, and issues of reliability and validity remain the same (4). What is different is the focus of concern. The following table lists the main cognitive skills as identified by Bloom (5) and gives examples of the emphasis to be assessed in socially relevant programmes.

Assessing General Mental Skills for Social Relevance

Mental Skill	Assessment Emphasis within Socially Oriented Biology
1. Knowledge Recalling specific and general items of information and also information about methods, processes and patterns.	Tests of recall of concepts, methods and processes of biology basic to specific social issues. And Recall of elements of a relevant social issue or problem.

Mental Skill	Assessment Emphasis within Socially Oriented Biology
1. Cont.	Example Recall of ecological principles eg. food chains in a fresh water lake. And Recall of elements in a case study of pollution of a lake.
2. Comprehension Recognizing items of information in settings similar to but different from those in which they were first encountered.	Tests of recognition and interpretation of a biological concept in a social setting. Example Recognition of the elements of the carbon cycle first introduced in a forest ecosystem when described for an urban environment.
3. Application Explaining previously unseen data or events by applying knowledge from other situations.	Assessment of ability to explain a social phenomenon in terms of biological principles. Example Application of principles of human physiology in an exploration of the medical procedures involved in surrogate motherhood.
4. Analysis Breaking down blocks of information into elements for the purpose of clarification.	Tests of ability to analyse a biology-related social issue in terms of both its biological content and its social dimensions. Example Given a short report of a case of illegal additives in food, identification of those aspects of the case which are basically about the chemistry and biology of food and those aspects which have social implications.
5. Synthesis Building information from previously separate units of knowledge.	Tests of skill in describing, reporting or reviewing a situation in society with some basis in biology or with implications for biology. Example Essay on the role of biologists in contributing to world peace.

Mental Skill	Assessment Emphasis within Socially Oriented Biology
6. Evaluation Making judgement about the value of information, materials or methods for given purposes.	Assessment of the relative merits of information, materials, proposals for action, procedures and so on in social controversies having some links with biology. Example Debate on the pros and cons of constructing a freeway through a unique community of natural bushland.

As mentioned in the introduction to this chapter, because programmes of socially relevant biology foster problem solving, critical thinking and evaluation of possible alternatives it is the higher order mental skills which should receive most emphasis. The skills of analysis, synthesis and evaluation are critical in reviewing case studies and in ensuring that the interactions between the purely scientific content and the social elements of each case study are fully understood.

(b) Assessing Specific Mental Skills in the Framework of Science

As listed in the introduction to this chapter more specific mental skills involved in science build on basic knowledge and comprehension of scientific concepts and involve criticism and analysis, creativity, deduction and inference, realism, accuracy, numeracy and literacy.

All these attributes should be assessed in relation to biology-based social issues. Criticism and analysis of social issues and concerns should involve identifying and understanding the scientific and social components of the issues and their interrelationships. Issues should be interpreted creatively with innovative and future oriented alternatives and solutions proposed and explored. The consequences of proposed actions should be understood and problems should be approached realistically and as objectively as possible. Case studies should be selected which help build both scientific and general literacy and which have quantitative elements to foster numeracy skills.

Any programme of cognitive assessment should express these skills in its objectives and assessment procedures should be developed to check on their achievement. Many examples of possible questions are given in Part II of this volume. In particular exercises in creative writing, in preparing reports, writing evaluative essays and in developing action plans are recommended. The more basic scientific numeracy and vocabulary elements of case study analysis can perhaps be assessed by more objective and shorter item formats such as problems involving multiple choice responses or short answers written in defined spaces.

(c) Assessing Knowledge and Understanding of the Processes of Science

As discussed in Chapter 8 Section 8.2, an understanding of the processes of science is a component of the broad spectrum of scientific literacy. As well as various descriptions of these processes given in Section 8.2 the list proposed by Klopfer (6) should be given consideration because it is especially helpful for designing assessment instruments in this area. The following table lists these process skills, indicates a possible emphasis for a socially oriented biology programme and comments on suitable data gathering procedures.

Assessing the Processes of Science for Social Relevance

Process Skill (After Klopfer)	Assessment Emphasis Within Socially Oriented Biology	Suggested Assessment Procedure
1. Observing and Measuring	Observation and measurement of both biological *and* social phenomena relevant to a specific issue. *Example* Observation of types and characteristics of microorganisms in polluted drinking water together with tabulations of estimates of relative abundance. *And* Quantitative analysis of medical records of incidence of gastro-enteritis in the affected community.	Questions based on a combination of both biological and social data requiring observations to be made and quantitative aspects to be interpreted. *Example* Data presented in diagrammatic form of microorganisms in polluted water together with table of relative abundances. *And* Statistical table of incidence of gastro-enteritis in the affected community. Multiple choice questions to check on understanding of (i) severity of the problem (ii) cause of the gastro-enteritis (iii) effect on the community (iv) possible action to solve the problem

Process Skill (After Klopfer)	Assessment Emphasis Within Socially Oriented Biology	Suggested Assessment Procedure
2. Seeing a problem and seeking ways to solve it.	Development of hypotheses to explain the biological basis of a societal problem and the choice or design of suitable experiments and/or other procedures to test the hypothesis. Example Hypotheses to be developed to explain high incidence of soil erosion in a crop farming region. Proposals for methods to test the hypothesis eg. analysis of historical records; interviews with farmers to check on farming practices and studies of the characteristics of the soil.	Open questions to explain nature and causes of a social problem with a basis in biology. Example Presentation of photographs of well managed and eroded farmland. Descriptive case history of both situations with accounts of factors such as clearing of trees; use and non use of crop rotation, application of fertilizers, overcropping, grazing and so on. Series of questions provided to be answered in short sentences on the following aspects: (i) description of the two situations and of differences between them (ii) possible causes of the differences (iii) ways in which the actual cause could be determined
3. Interpreting data and formulating generalizations	Formulation of general policy in regard to a broad social issue with some basis in biology. Example Given patterns of imports and exports of biologically based products between two countries, analysis of trade balances and formulation of policies	Case study analysis of a broad biologically based social issue requiring the formulation of a general policy. Example Presentation of graphical data showing export earnings and import costs over ten years for two trading partner countries.

Process Skill (After Klopfer)	Assessment Emphasis Within Socially Oriented Biology	Suggested Assessment Procedure
3. Cont.	for debtor country to improve its production.	Products wheat, timber or canned meat. Tests to assess skill in writing an extended essay (i) describing the trade patterns and the trade imbalances between the two countries and (ii) proposing development policies for the export products of the country with the least favourable balance of payment.
4. Building, testing and revising a theoretical model.	While this is relatively straight-forward within the framework of pure biology (eg. a model to explain the world distribution of mammals in terms of climatic adaptation) it is more difficult in socially oriented situations because of the complexity of the variables. But it is possible to provide guidelines such as "input-process-output-feedback" which could be applied to science-based social situations. Example Develop an overall scheme to show the origin, flow and use of biology-based energies in a given community such as farming area or a city. And Development and application of criteria to test the validity of the scheme.	Test to determine skill in development of a general model or scheme to describe and/or explain a complex situation involving interactions between biological and social variables. Example Given a detailed account of inputs, usages and outputs of energy in an urban housing estate students to draw diagrams and provide a written description of flow charts and balance sheets which give a comprehensive schematic overview of the sources and utilization of energy in the estate. In addition, identification of energy problems and suggestions for their resolution could be required.

Process Skill (After Klopfer)	Assessment Emphasis Within Socially Oriented Biology	Suggested Assessment Procedure
5. Applying scientific knowledge and methods	Application of the concepts and principles of biology in analysing and evaluating solutions to social controversies and problems. Example Application of knowledge of alternative biological and legal definitions of death in the analysis of specific cases involving, for example, abortion, withdrawal of life support systems from terminally ill patients or organ transplants.	Evaluation of alternative solutions to controversial case studies. An essay or series of short-answer questions based on descriptive text and requiring the application of biological knowledge. Example Students presented with description of a medical case involving a "brain dead" patient for whom the relatives wish to maintain life support systems. The medical profession recommends their withdrawal. Students to answer questions such as the following: (i) Is the patient dead? What definition of "death" should apply in this case? (ii) In what ways could the type of definition of death affect the outcome of this case? (iii) What, if any, are the goals, rights and duties of the patient, the relatives and the doctors in the above case? (iv) How could a clear understanding of the definition of death help all parties in this dispute reach a solution satisfactory for all?

The assessment of understanding and utilization of the processes of science within a programme of socially oriented biology should, in effect, show that a scientific approach with its rigour and with its focus on relatively objective data and on relatively unbiased decisions based on hard evidence, is a powerful aid in understanding social issues and in resolving problems and conflicts in society. Unless the links between use of the processes of science within the framework of biology and their use in social settings are made overt, then school biology will remain an isolated "subject" taught for its own sake and having little or no general educational significance.

(d) Ensuring Transfer of Understanding Between Biological Concepts and Social Issues

To illustrate the last point about transfer from biological to social settings, three possible assessment questions are given below (see box).

Theme. Teenage drug abuse

Test question 1: Write an account of how the drug heroin affects (i) the nervous system (ii) the muscular system and (iii) the functions of the reproductive system.

Test question 2: "Heroin is a major social problem, especially among teenagers living in cities". Describe and discuss some of the social and economic consequences of the widespread use of illegal drugs such as heroin.

Test question 3: "The use of addictive drugs such as heroin adversely affects the normal functioning of the body and has a negative effect on society as a whole."
Give some examples of how the biological effects of using heroin can have social consequences. What could be done to warn people of the health and social risks of taking illegal drugs?

Test question No. 1 would be appropriate for a conventional biology programme. It focuses on the physiological problems of drug abuse. Any implications for the social wellbeing of an individual user or for the impact of drugs on society as a whole are implied and not made overt. Transfer of knowledge from the framework of biology to implications for everyday life is left entirely to chance. There is no doubt some transfer will occur but it is not clear how much or how effective will be the understanding of social aspects.

On the other hand, test question No. 2 is entirely a socially oriented question. It could be answered without reference to any biological principles at all. This may be appropriate within a course of social studies or civics but not within a programme of biology. The whole point about teaching biology for social relevance is that problems such as those posed by question No. 2 can be better understood and are more likely to be solved if the biological basis of the problems is known and understood. If the question does not ask for knowledge of the biology this aspect may be totally missed and the response will be inevitably superficial and largely ineffectual.

Question No. 3 links the biology with the social issue in such a way that the biological basis of the problem is made overt. Understanding of the social implications is sought openly and directly. Bridges between the science and its social dimensions are clear to both student and teacher and it is highly likely that transfer will occur.

Many advocates of the conventional "subject oriented" approach to school level biology argue that if the scientific concepts are well taught and well understood then their societal implications will be automatically applied in appropriate situations as needs arise. The psychological evidence for this, however, suggests that unless teachers deliberately link the two areas - science and society - transfer is unlikely or at best will be partial or possibly distorted. Assessment programmes, therefore, should ensure that the links are clear.

(e) Evaluating the Effectiveness of a Cognitive Achievement Test for Social Relevance

In any well designed and well administered programme of assessment the individual elements, whether used for the purpose of grading or for some other purpose, should be evaluated for their effectiveness in measuring achievement of the course objectives. This is especially important in an experimental curriculum such as the socially oriented approach advocated in this volume. A set of criteria for judging the appropriateness and effectiveness of a specific cognitive achievement test is given below (7).

Evaluation of a Specific Cognitive Test

Evaluate the suitability and effectiveness of the test on the following ten criteria, using the rating scale below:

4 = very satisfactory - no amendments needed
3 = satisfactory - minor amendments only
2 = unsatisfactory - considerable amendment required
1 = very unsatisfactory - major revision

Indicate the ratings by placing a cross (x) in each column 4, 3, 2 or 1, opposite each criterion. Join each cross by a straight line to develop an evaluation profile.

Criterion	Rating			
	4	3	2	1
1. All questions are relevant to the socially oriented cognitive objectives of the course.				
2. There is a balance between all aspects of intended achievement and especially between the biological and societal components.				
3. The test is efficient in terms of time for administration, scoring and grading.				
4. All questions are sufficiently objective and definite to ensure high levels of agreement on the answers by experts in both biology and social studies.				
5. All questions require achievements specific to the fields of biology and social studies so that intelligent students not taking the course could expect scores at the level of chance.				
6. The majority of questions are at an appropriate level of difficulty.				
7. All questions are likely to discriminate between students of higher and lower achievement.				

Criterion	Rating			
	4	3	2	1
8. The test is likely to give reliable scores, agreeing with those obtained by alternative tests of the same achievement				
9. The test as a whole is fair, all students having a reasonable and equal chance to demonstrate achievement.				
10. The test is the right length for the time allowed so that rate of work has minimal influence on the score.				

Data from this type of evaluation are useful not only to improve the technical effectiveness of the assessment programme as such, but are also helpful in evaluating the overall effectiveness of the total curriculum. By applying such lists of criteria teachers can check if they are keeping the central concerns of the total programme in central focus.

10.3 Conclusion

As shown by Professor Peter Kelly (8) issue studies are generally more complex than knowledge studies. Issue studies tend to emphasise problem-solving and critical thinking; to involve many unknown or at least uncertain variables; to be usually initiated by a concern for societal or individual action; tend to have a high moral and ethical load; tend to involve somewhat confused terminology and to have an eclectic integration and variable arrangement. This is in sharp contrast to the more ordered characteristics of conventional "knowledge" studies characteristic of a classical programme of school biology.

This has considerable implications for the assessment of cognitive elements in a course of socially oriented biology which is made up mainly of "issues" studies. In the first place test questions become more elaborate based on complex stimulus material, frequently involving lengthy descriptions or an elaborate display of data. The questions posed should probe for the higher order mental skills, especially application, analysis, synthesis and evaluation. The focus should be on problem-solving and the development of critical thinking.

Students undertaking this type of course need to have a good standard of general literacy and of scientific literacy. For example, they should have a good scientific vocabulary; understand the broad concepts and processes of biology and have a clear understanding of their application outside the framework of the formal discipline. This implies also that they should have a broad general knowledge and in particular a sensitive knowledge of current affairs.

Much of the stimulus material for test questions in this type of programme should be based on material taken from the mass media - especially newspapers and readily available magazines which comment on current affairs. This implies that students should be encouraged to read widely and critically and that is one of the important aims of this approach to course design and to the types of assessment procedures advocated in this volume.

The ultimate aim is to make students effective in daily life so that day-to-day personal and community decisions will be based on reasoned understanding. Appropriate, cognitive tests, whether for grading or non-grading purposes, contribute significantly to achieving this aim.

Notes and References

(1) Bloom, B.S. Taxonomy of Educational Objectives: The Classification of Educational Goals: Handbook I Cognitive Domain. New York, David McKay Co., 1956.

(2) Based on Bloom, B.S. Ibid. as cited in Eggleston, James F. and Kerr, John F. Studies in Assessment. Liverpool: The English Universities Press Ltd., 1969.

(3) Klopfer, Leopold E. "Evaluation of Learning in Science" in Bloom, Benjamin S.; Hastings, Thomas J., and Madeus, George F. Handbook on Formative and Summative Evaluation of Student Learning. New York: McGraw-Hill, 1971, pp 559-641.

(4) See for example Unesco: Unesco Handbook for Biology Teachers in Asia. Paris: Unesco, 1986, pp 551-571.

(5) Op.cit. Note 1.

(6) Op.cit. Note 3.

(7) Modified from: Meyer, G. Rex; Jenkins, Carole, and Chan, Evalina, Developing a Program for Assessment of Student Performance Second Edition (Processes of Teaching and Learning Minicourse M22). Sydney: Macquarie University Continuing Education Program, 1981.

(8) Kelly, Peter J. Science Life and Education (Inaugural Lecture). London: Chelsea College University of London, 1977.

Chapter 11

ASSESSING ATTITUDES, INTERESTS AND VALUES

11.1 Introduction

The hierarchy of educational objectives proposed for the cognitive domain by Benjamin Bloom was reviewed in Chapter 10. Similarly the hierarchy of educational objectives proposed for the affective domain by colleagues of Bloom are central to any programme assessing emotive variables such as attitudes, interests and values (1). This affective hierarchy refers to (i) willingness to receive or attend to given stimuli; (ii) willingness to respond by seeking out or working with a given subject or activity; (iii) willingness to value something to the extent of holding convictions about it; (iv) willingness to organize values into a coherent system, and at the highest level of the hierarchy; (v) willingness to integrate beliefs, ideas and attitudes into a total philosophy or world view (2). This hierarchy therefore suggests that if students have positive attitudes and values they are attracted to the attitude object and demonstrate willingness to be involved in it or to be associated with it. Students with positive attitudes to science enjoy studying science and show willingness to participate in science-based activities. Assessment of variables, therefore, involves measuring the degree of attraction towards something and the degree of willingness to become involved in, engage in, or value particular areas of knowledge or activity or complexes thereof.

Since socially relevant biology involves the development of positive attitudes to the resolution of social problems and conflicts, and since it frequently demands a sensitive approach to the analysis of conflicting systems of value, the assessment of variables in the affective domain are of central importance.

Unfortunately the achievement of affective objectives is not as easy to test objectively as the achievement of cognitive objectives (Chapter 10) or of objectives concerned with manual skills (Chapter 12). Students can be asked to express their opinions about an issue or to state their levels of interest in or attitudes towards something, but teachers cannot always be confident that answers will reflect true emotions. The degree of openness and frankness reflected in the replies will be influenced by the use to be made of the assessment results. Clearly if they are to be used as a component of grading, students will tend to give answers likely to maximize their grades rather than those which express their true feelings.

For these reasons testing of achievement in the affective domain tends to be neglected in competitive terminal examinations and as a result, affective concerns are frequently under emphasised in the classroom. This is a matter for serious concern within any subject including even the most classically oriented programme of school biology. In a biology course with a focus on society, however, it is totally inappropriate and must be addressed.

There are several ways to resolve this problem. In the first place it has been stressed that continuous assessment across a broad range of variables is recommended for a programme of socially oriented biology (Chapter 9). Not all elements of such an assessment programme should be for the purpose of grading. Certain affective variables can be assessed as part of the non-grading components and if students are convinced that results will be used for purposes such as educational counselling, course improvement or for upgrading resources, they will answer honestly and openly.

Secondly it is recognized that all affective variables have a cognitive component. If assessment of attitudes towards or interests in some area of biology or its applications is required for the purposes of grading, evaluative aspects of the cognitive component can be highlighted. For example an indirect clue as to attitudes and values can be obtained by asking students to select which of a series of methods or procedures may be appropriate for solving a particular social problem. Strictly speaking, such a question is in the cognitive domain but if the question is appropriately worded, it may reveal something about attitudes and values relevant to the social problem under review.

There is a third option. While objective "student proof" approaches to affective assessment are admittedly difficult to devise, it is possible to design some test items which cannot be answered according to students' perceptions of what the teacher requires. One technique is to give a list of concepts or statements and ask students to select or highly rate those which most interest them. If the students are unaware of what the teacher has coded as the area being evaluated then unbiased answers are given. For example, students may be asked whether they prefer to use the microscope, perform experiments or do field work. There is no right or wrong answer and the analysis depends on which procedure the teacher wishes to investigate.

The hierarchy of affective objectives proposed by Bloom's team of psychologists has universal application. In a programme of socially relevant biology, however, the assessment of these various levels of the hierarchy must be concerned with the relationship between biology and societal issues. In a course of traditional biology affective tests should probe, say, at the degree of willingness of a student to listen to talks on or to read about topics such as photosynthesis or renal function. In a socially relevant programme there should be assessment of willingness to listen to and receive messages about biology related social problems such as pollution control or how biology can promote national development.

Another aspect of assessment in the affective area within any type of science course is the need to check on students' development of positive scientific attitudes. These include willingness to observe and record phenomena, to suspend judgement, to weigh evidence and so on. In a programme of socially relevant biology the emphasis should be on assessing positive scientific attitudes in resolving social problems and in analysing and evaluating social issues.

Finally transfer from the school setting to the real world of day-to-day living depends not only on building bridges between science and society in terms of knowledge and understanding, but also on establishing a climate of willingness to apply biological understanding in a social context. It follows that development and assessment of appropriate socially oriented attitudes is critical. These include positive attitudes towards the role and power of biology as an agency for social change, a willingness to become involved in debating and resolving biology-based social conflicts, and an objective unbiased empathetic approach to clarifying values and to facing ethical and moral dilemmas of personal and community concern.

The main point about assessment in the affective domain within a programme of socially-oriented biology, is that since course objectives focus on emotive issues and contrasted systems of values, on resolving conflict between opinions and on the development of unbiased judgement, tolerance, sensitivity and empathy, then it is the affective component which probably has the most important role in directing learning and ensuing appropriate personal development. Assessment involving the clarification of values is of critical importance.

11.2 **Principles and Procedures**

(a) Assessing General Affective Objectives

As in the case of the cognitive domain (Chapter 10) technical aspects of affective assessment are similar in both socially oriented or conventional biology - again the differences are in the foci of concern.

The affective hierarchy proposed by the team of psychologists working under the direction of Benjamin Bloom provides a useful framework as it does in the case of the cognitive domain (3). There is, however, one significant qualification. The higher levels of cognitive objectives such as synthesis and evaluation are fully attainable within a programme of school biology and should be a central focus for assessment in any socially oriented curriculum. In the case of the affective domain the higher order objectives such as the organization of values into a coherent system of personal relevance and the integration of beliefs, ideals and attitudes into a total personal philosophy or world view, are hallmarks of considerable levels of personal maturity which may not be attained by all school-age students. The aim of a socially-oriented programme should be to facilitate personal growth towards the achievement of these important objectives and therefore some assessment of their degree of attainment is desirable. There is no doubt, however, that a programme of biology which focuses on social issues and the development of attitudes of social accountability and responsibility is more likely to develop these mature personal characteristics than a programme limited to a consideration of biological concepts alone.

The following table lists the five levels of affective objectives proposed by Bloom's colleagues (4) and gives examples of the emphasis to be assessed in socially relevant programmes of secondary school biology.

Assessing Affective Objectives for Social Relevance

Affective Objective	Assessment Emphasis Within Socially Oriented Biology
1. Receiving Sensitivity to certain stimuli and a willingness to receive or attend to them.	Assessment of willingness of students to listen to and attend to information presented to them about the relationships between biology and society. Example Use of class observational schedule to rate behaviour of individuals and of whole class in terms of attentiveness during presentations such as (i) a relevant talk by the teacher, (ii) a talk by a visiting social worker and (iii) screening of a relevant film or video on a socially significant issue.
2. Responding Involvement in a subject or activity or event to the extent of seeking it out, working with it or engaging in it.	Assessment procedures to check if students voluntarily listen to, read or otherwise receive messages about the role of biology in society. Example Over one month the periodical and newspaper articles read by students monitored by an objective system or by a self-check inventory in defined categories such as: (i) sports (ii) the arts (iii) research biology (iv) biologically based social issues. Profiles made of reading preferences of individuals and of the class as a whole.

	Data used as basis for class discussion of various patterns and motivations.
3. Valuing Commitment to a conviction in certain goals, ideas or beliefs.	Tests to assess the degree students believe in, have faith in or are willing to accept given views about the value of concepts, ideas, plans, procedures, solutions and policies within socially sensitive areas with a basis in biology or with some links with biology. Example Review questions based on a case study of policy in regard to logging in natural forests to supply timber for preparation and export of wood pulp. Alternative policies proposed with reasons advanced by their advocates and students to select and defend one of the alternative positions. Possible alternatives could include: (i) Natural forests should not be pulped because of the destruction and possible extinction of rare species. (ii) Economic gain is more important than protecting a few rare plants and animals and so the forests should be pulped. (iii) All natural forests should be preserved for future generations as pulping totally destroys them and should be banned. (iv) Some native forests should be left for future generations but some could be pulped and exported to help our balance of trade. (v) Only cultivated forests should be pulped because we have a responsibility towards the preservation of species other than our own. . . . And so on.
4. Organization of Values Organization of values into a system, awareness or relevance of and relations between appropriate values and the establishment of dominant personal values.	Assessment of students' appreciation of the convergence of multiple systems of values in determining a course of action or formulating policies by individuals or groups within the framework of biology-related social issues. Example Essay or report to review the values at the basis of those aspects of the nation's current five year plan for economic develop-

	ment which are related to biology or which have links with biology. Writing on the following: (i) Identify the main biologically-based elements of the plan. (ii) Discuss the value-systems at the basis of each proposal (eg. respect for individual rights; belief in sustainable development; appreciation of need for international cooperation and so on). (iii) State personal attitudes to each aspect of the plan with a discussion of why that attitude is held.
5. Characterization of a Value Complex Integration of beliefs, ideals and attitudes into a total philosophy or world view.	Assessment of degree to which a student has developed a coherent world view or philosophy and the degree of consistency in applying it to an understanding of socially relevant situations and problems with some basis in biology. Example (a) Tests to review the depth and consistency of applying scientific principles and methods to the resolution of social problems. (b) Tests to see consistency of application of an ethical system in proposing solutions to bioethical dilemmas such as: (i) experiments with human embryos (ii) gamete freezing and cross-generation fertilization (iii) gene splicing in humans

Clearly many aspects of assessment within the affective domain are inappropriate for gathering direct evidence for the purpose of grading. Since many areas (particularly at levels 4 and 5) of the affective hierarchy involve a long-term development of the whole person, assessment data in these areas are valuable in fostering personal development through sensitive and appropriate educational counselling. The important point in relation to courses of biology with a social orientation is that the curriculum structure of such courses provides a more useful and appropriate framework for fostering such personal development than does the curriculum structure for conventional biology.

(b) Assessing the Scientific Attitude

With few exceptions (5) science educators agree that there is an important affective area termed "the scientific attitude" and that this attitude should be fostered within programmes of school science. All agree, however, that there are several dimensions to the scientific attitude and while there is some variation in opinion about the precise nature of these dimensions, the variations are minor and the overall pattern is much the same from author to author. To illustrate this point lists of the dimensions or components of the scientific attitude as identified by three authorities are given below.

The Components of the Scientific Attitude as Identified by Three Authorities

Jones (6)	Billeh and Zakhariades (7)	Kozlow and Nay (8)
1. Concern for evidence	1. Rationality	1. Critical mindedness (questioning attitude)
2. Belief in natural causation	2. Curiosity	2. Suspended judgement (restraint)
3. Willingness to accept new evidence.	3. Open-mindedness	3. Respect for evidence (reliance on fact)
4. Willingness to seek alternative sources of information	4. Aversion to superstition	4. Honesty
5. Willingness to suspend judgement	5. Objectivity/ intellectual honesty	5. Objectivity (open-mindedness)
6. Intellectual honesty	6. Suspended judgement	6. Willingness to change opinions

The similarities between the lists produced by the three authorities are obvious and are mainly in the wording used rather than in the meaning of the underlying concepts.

Several authors have constructed tests of scientific attitude based on these types of components. An example by the present author is reproduced below (9).

A TEST OF THE SCIENTIFIC ATTITUDE

IV TALKING TOGETHER

On another day the same group of girls and boys talked together about different things that interested them at the time. Here are some of the things they said. Give 4 votes to those which are most like what you would have said, 3 for the next most sensible ones, 2 for the next, 1 for the ones with which you agree least, and 0 for the ones with which you do not agree at all.

Put your vote on the black line at the side. Be sure to give some kind of vote to each one. Use 4, 3, 2, 1 or 0 as often as you like.

1. I like learning about latest discoveries and inventions .. .. .. ______
2. I do not like to be told the answer to a problem, I like to work it out for myself .. .. ______
3. I am satisfied with the knowledge I have now and I am not keen on learning new things .. .. ______
4. I usually believe everything that is written in books except story books .. .. .. ______
5. People who are different from us are usually bad people .. .. ______
6. When people carry out experiments they should repeat them to see if they get the same results .. .. ______
7. People with new ideas are usually a nuisance and are often dangerous .. .. .. ______
8. I prefer to finish a project myself to make sure the same method is used throughout .. .. ______
9. I try not to listen to people who argue with me that my beliefs about scientific things are not true beliefs .. .. ______
10. I think it's a good thing to be curious about other people and about the world in which we live .. .. ______
11. I enjoy reading and hearing about things which disagree with my previous ideas .. .. ______
12. An important aim in life is to find out about new things .. .. .. ______
13. If two events occur at much the same time it is reasonable to conclude that one is the cause of the other .. .. ______
14. I usually make up my mind quickly, and do not often change it in spite of what other people may say .. .. ______
15. I play safe and follow superstitions because I do not want to have bad luck .. .. ______
16. I enjoy experimenting with new things .. .. ______
17. Those who are always definite and certain about things are the wisest people .. .. ______
18. I like to investigate statements to make sure they are correct .. .. ______
19. I always try to make several observations before I am satisfied I have made the correct one .. .. ______
20. I get bored when I hear about new discoveries and inventions .. .. ______

A single reliable and valid "scientific attitude" score can be obtained from the above test by separately adding the ratings in the left and right columns and subtracting the total of the right column (negative attitudes) from the total of the left column (positive attitudes). Alternatively single items from the test can be used in single questions polls.

Within a conventional programme of school biology assessment of the scientific attitude, as a whole, or of its specific components, should be mainly concerned with checking on consistency of application in learning about the concepts and processes of biology as such. In a socially-oriented programme it is the consistent application of all aspects of this attitude in the analysis and evaluation of social issues and in the resolution of social problems and conflicts which should be the central concern.

If a student is willing to apply a relatively objective scientific approach to the resolution of relevant social issues then there will be less bias and prejudice, and confrontation is more likely to be replaced by tolerance and conciliation. Assessment, therefore, should use the case study approach and test (i) whether students appreciate if conflicting viewpoints are derived from a scientific or an unscientific approach and (ii) if students can analyze the situation scientifically and free from personal prejudice and bias.

(c) Assessing Relevant Social Attitudes

Apart from those attitudes specifically relevant to science, a socially oriented biology programme should also foster, and so assess, the development of positive social attitudes. Many of these are related to or derived from the scientific attitude. Socially significant attitudes include the following:

- Respect for the rational views of others
- Tolerance of ambiguity
- Willingness to search for relevant knowledge in resolving conflicting points of view
- Sensitivity to cultural differences
- Willingness to resolve conflicts rationally
- Willingness to control aggression in resolving conflicts
- Valuing the worth of individuals
- Judging people of different races, cultural and ethnic origins in terms of their behaviour as individuals
- Willingness to participate in democratic decision making
- Positive attitudes to personal life planning and to personal development
- Personal confidence and a positive self image in facing the problems of daily living

. . . And so on.

Several examples of assessment projects and test questions which focus on these types of attitudes and values have been given in Part II. It is important that they be given prominence in any programme of affective assessment within the framework of a socially relevant programme of biology. Some of the formats and types of items suitable for this type of assessment are briefly reviewed below (Section 11.2 d).

(d) Formats and Types of Assessment Techniques Suitable for Socially Relevant Biology

Most readers will be familiar with the range of item formats appropriate for cognitive assessment: essays; report writing; creative writing; writing, drawing and calculating in defined spaces; multiple choice; true-false; matching, and completion formats. This volume made no attempt to review these familiar formats within the cognitive domain (Chapter 10) and readers are referred to the helpful Unesco volume in its Science and Technology Education Document Series on this subject (10). Similarly it is beyond the scope of the present volume to describe and discuss in detail the various formats for assessing affective outcomes. Nevertheless because this area may be relatively unfamiliar to some readers brief notes are provided on the more widely used approaches to affective assessment. For more detail on these approaches the excellent publication Basic Measurement and Evaluation of Science Instruction written by Rodney L. Doran for the National Science Teachers Association of the United States is highly recommended (11). For a general account of assessment techniques in the affective domain readers are referred to the pioneer work by H.H. Remmers and N.L. Gage, Educational Measurement and Evaluation (12) which remains a standard reference in this area.

Before presenting a summary of useful formats one further point should be made. It is this: Many of the techniques used for cognitive assessment can be utilized for affective assessment - especially the more subjective formats such as essays, report writing, creative writing and so on. More structured approaches such as multiple choice, true-false and completion formats may be used but must be carefully designed to be appropriate for checking on affective objectives and they also must be interpreted appropriately.

The following formats and techniques are especially recommended for affective assessment within a programme of socially relevant biology. Few, however, are sufficiently objective for the purposes of grading. They are useful for educational counselling and for curriculum evaluation.

i) Multiple Choice Formats. These are useful for assessing levels of interest in specified categories. For example, students can be asked to select from a range of alternatives those which hold most interest for them.

Example 1. Relative interest in "types" of biology

. Of the following the area of study which most interests me is:
  (a) latest research findings in biology
  (b) how scientists make biological discoveries
  (c) the use of biology in solving social problems
  (d) the natural history of plants and animals

A battery of such questions (ten or more) would enable scores to be taken out in areas such as research outputs, methods of biology, social applications and natural history.

Example 2. Relative interest in various social themes

. Of the following I would like best to know more about -
  (a) biology and family life
  (b) how biology can contribute to national development
  (c) biology and the management of game parks and natural history reserves
  (d) biology and health

Multiple choice formats can require students to select the most preferred single alternative or they may be used as short inventories requiring a rating on each alternative from say 0 "little or no interest" to 4 "high level of interest". Summated ratings across a series of such questions can provide interest profiles for individuals and groups.

Cognitive aspects of the affective domain can be assessed using multiple choice formats. In such instances the scores could possibly be used for grading but then that would assume that a particular viewpoint was required of all students.

Example 3. Role of biologists in society

. Some people argue that scientists such as biologists should be concerned only with scientific aspects of the study of living things. Others say that biologists should be concerned about the uses made of biology in society. Which of the following statements do you endorse?

  (a) Biologists should stick to their laboratories and not get involved in social issues because they have vested interests in promoting their own work.

  (b) The work of research biologists is so specialized that biologists would not be able to participate in decisions about how their work might affect the community.

  (c) Biologists are members of society and so they have a responsibility to help the community understand and make use of their work.

  (d) It would be dangerous for society if biologists tried to influence the community in how their findings should be used by the community.

ii) Rating Scales. Students may be given an extended list of statements or topics and rate them on an (1) agreement scale (strongly agree through neutral to strongly disagree) (2) interest scale (0 is little to 4 maximum interest) or (3) preference for action (would greatly dislike doing that through neutral to would greatly like doing that).

Example. Social participation inventory

. Rate each of the following 4, 3, 2, 1 or 0 according to how much you would like to do that kind of thing.

4 = I would like to do that very much
3 = I would rather like to do that
2 = I don't care much either way
1 = I would rather dislike doing that
0 = I would not like to do that at all

	Rate 4, 3, 2, 1 or 0
1. Write an article for the school newspaper on organizing a local "clean up" campaign	____
2. Visit the local hospital to study the way it helps the local community keep healthy	____
3. Interview people to find out what they think about national parks .	____
4. Make a chemical and biological investigation of polluted drinking water from a local supply	____
5. Write a report to the government on arguments for and against building a freeway through an area of bushland	____
6. Organize a political campaign against logging in natural forests .	____
7. Write letters to the United Nations to protest about the torching of tropical rainforests in various countries	____

. . . And so on.

iii) Likert Attitude Scales. These are special forms of rating scales originally devised by the American psychologist Renis Likert in the 1930s (13). In spite of its age this method remains one of the most widely used for affective assessment.

Attitude statements are listed and students judge them on a five point scale from strongly agree, agree, through neutral or uncertain to disagree and strongly disagree. Total scores can be obtained by converting the verbal statements to numerical ratings (5 through 3 to 1) or alternatively the number of students responding to each position (1 to 5) for each statement may be recorded.

Example. Attitudes to the usefulness of biology in solving social problems

. For each of the following statements vote on whether you agree or disagree. Vote on the following scale.

Draw a circle around SA if you strongly agree
Draw a circle around A if you are in partial agreement
Draw a circle around N if you are neutral
Draw a circle around D if you partially disagree
Draw a circle around SD if you strongly disagree

1. Knowing about biology is helpful in solving many of the problems of day-to-day living. SA A N D SD

2. Governments should make use of biological knowledge when preparing plans of economic development. SA A N D SD

3. The study of biology helps the community plan for sustainable development of natural resources. SA A N D SD

4. A good national health scheme depends on the people-in-charge understanding a good deal about biology. SA A N D SD

5. Families would be generally better off if parents knew something about biology. SA A N D SD

. . . And so on.

iv) Semantic Differential. Like the Likert technique this method is well established. It was originally developed by the psychologist Charles Osgood and colleagues in 1967 (14). A list of bipolar objectives is provided in relation to an object or situation and, usually, a seven point scale is provided between the words in each pair. Students indicate their views by checking one of the seven points on the continuum between the words.

Example. Attitude to biologists as agents of social change

BIOLOGISTS AS PEOPLE WHO AFFECT SOCIETY ARE

Very helpful	. . . .	Don't help at all
Caring	. . . .	Dangerous
Useful	. . . .	Useless
Good	. . . .	Bad
Exciting	. . . .	Boring
Necessary	. . . .	Unnecessary

Easy . . . . Troublesome
Imaginative . . . . Unimaginative
Interesting . . . . Boring
Clear . . . . Confusing
Important . . . . Unimportant

By giving numerical values to the 7 points lying between each of the paired words scores for individuals or groups can be calculated. Alternatively points chosen can be joined by straight lines to give visual profiles. These types of devices are useful for educational counselling and for curriculum evaluation.

v) Personal Discussions and Interviews. These more direct approaches are very useful for obtaining qualitative data about attitudes, interests and values. Interviews should be carefully structured and questions should be asked as objectively as possible. For example

1. Which area of biology interests you most?
2. If you were investigating social problems with some relationships with biology which types of problems would most interest you?
3. What sort of job would you like after you leave school?

Replies can be recorded and written out in full or briefly summarised after the interview or discussion. They could be left as anecdotal descriptions or rated in various ways against sets of criteria.

vi) Student Project Reports and Written Exercises. Frequently reports submitted on factual aspects of biology or on their relation to social issues reveal something about levels of interest or about attitudes and values. Like interview data anecdotal records can be kept or answers can be rated against agreed criteria.

vii) Subjective Questions. Students can be invited to write out short or longer answers that involve value judgements.

Example

The local government has proposed a scheme to use unemployed youth to build nature trails for bushwalkers in national parks. What do you think of this idea? Will it help conserve plants and animals or will it help destroy them? Will the scheme benefit or disadvantage the community? What advice would you give on this matter?

Scores or ratings can be given for various aspects such as

- knowledge of biology
- clarity of expression
- clear statement of relative values
- objectivity

viii) Behavioural Checklists. A simple technique involving the listing of relevant behaviours. Students indicate by a rating the extent to which they perform each behaviour - say, each day, about once a week or about once a month.

Example. Checklist of socially relevant behaviours

	Never	Daily	Weekly	Monthly
Read newspaper articles about social problems involving biology.				
Work to earn pocket money doing something involving plants or animals.				
Talk to my family about social problems that have links with biology.				
Find out as much as I can about the biological ideas I hear about on television.				
Visit museums, botanical gardens or any place where I can see plants and animals.				

. . . And so on.

ix) Q-Sort. This is an especially effective method of assessing attitudes. Emotive words or phrases are written on about 50 or so cards. Some are highly positive and some highly negative. Students are required to sort the cards into five or more groups from, say, 1 least like his or her views to 5 most like his or her views, or from 1 least agreeable to 5 most agreeable, or from 1 least representative to 5 most representative. The piles may simply be inspected by the teacher to gain impressions of attitudes or the numbers in each pile can be counted and median ratings calculated.

Example. Self Image

Fifty cards to be sorted in five groups from least to most representative of personal behaviour. Words such as the following on the cards: lazy, competent, get things done, follow directions, observant, active, leader, clumsy, keen, bored, enthusiastic and so on.

x) Projective Methods. These are open-ended questioning techniques which encourage students to express their attitudes, interests and values freely and openly. Relevant pictures or incomplete sentences are presented to students who are invited to make up a story about the picture to suit themselves or to complete the sentences in any way they like.

Example 1. Attitude to forest conservation.

Pictures presented of (a) logging in rainforest (b) undisturbed rainforest (c) uses of rainforest timbers. Students invited to write a story about each with themselves as the main character.

Example 2. Attitude to science as a method of social inquiry.

Students invited to complete sentences such as the following:

Biology in society is ______________________________

An argument against using biology to solve social problems is ______________________________

People like to use biology to help solve social issues because ______________________________

One thing that makes many people unhappy about biology is ______________________________

Answers can be interpreted qualitatively or rated against agreed criteria.

xi) Thurstone Attitude Scales. These are frequently used in the area of attitude assessment (15). In some respects they are similar to Likert Scales but are a little more complex to construct and interpret. A Thurstone Attitude test consists of a series of attitude statements which have been pre-judged and rated on a nine point scale by a panel of expert judges. An attitude value for each item is calculated using the median score of the judges. Students tick items with which they agree and the scale values of the items they select are added together to give an overall attitude score. It is beyond the scope of this volume to describe this method in any detail and readers are referred to the well known work of Billeh and Zakhariades who used the method to assess scientific attitudes (16).

(e) Assessment and the Clarification of Values

Since courses of socially relevant biology are mainly concerned with the study of social issues, the values components of the affective domain are of central importance. Students need to be comfortable and skilled in recognizing and dealing with contrasted values held by groups with contrasted views about a particular policy or proposed course of action. An approach which has been described in Part II of this volume (Section 7.6 for example) has been to identify the goals, rights and duties of various protagonists and to consider their characteristics and perhaps their origins (17). Assessment usually takes the form of an essay or report based on a case study of a controversial social issue. Students are asked questions such as:

- Describe the biological principles involved
- Identify the goals, rights and duties of the people for and against a proposed course of action
- Discuss the origin of the values held by the various parties
- Suggest possible alternative courses of action which would satisfy the various groups consistent with their values

Suitable case studies could be about medical problems involving withdrawal of life support systems from terminally ill patients, organ transplants, gene splicing and so on; or environmental issues involving clashes of interests between developers and conservationists.

There is, however, another aspect of values clarification. It is the need for individuals to come to terms with their own personal values and to approach personal decisions in life based on values held. Socially oriented biology can and should help students clarify their own values and to make wise personal decisions. This aspect, therefore, needs to be carefully assessed.

The American educator Louis Rath (18) suggests that valuing consists of seven sub-processes. These are listed in the first column of the following table. The table also suggests how these can be developed and assessed within a programme of socially relevant biology.

The Components of Valuing and Their Role and Assessment Within Programmes of Socially Relevant Biology

Sub-Processes of Valuing (After Louis Rath)	Role in Example of Socially Relevant Biology	Suggested Assessment Procedure
A. Prizing one's beliefs and behaviours.		
1. prizing and cherishing	Developing interest in and respect for people of different cultures.	Multiple choice preferences on alternative ways of viewing people from different cultures.
2. publicly affirming (when appropriate)	Writing a letter to the local Council protesting about a proposal to establish a land fill garbage dump near the school.	Ratings of the attitudes and values expressed in a letter - assessed against a set of criteria.

B. Choosing one's beliefs and behaviours		
3. choosing from alternatives	Making a personal choice of which of two local institutions most need financial support from school fund raising activities (eg. a local hospital and a retirement village for underprivileged citizens).	Given the policy statement of the two institutions, and descriptions of their budgets and programmes write a report listing arguments for and against financial support for each. Assessed in terms of both cognitive and affective analysis.
4. choosing after consideration of consequences	Expression of values and attitudes towards some situation with personal consequences for the student - eg. expression of concern for the cleanliness of the school neighbourhood in the full knowledge that this implies personal action.	Development of an action plan for a clean-up campaign with description of personal roles and responsibilities. Answers rated on quality and effectiveness of the plan and on degree of personal commitment proposed.
5. choosing freely	Given a series of possible actions in relation to a particular social issue choosing one which the student would prefer to follow. eg. A series of proposals for action to protest against logging in natural forests - selection of one proposal for action by the student.	Case study of proposal to log a national park followed by an inventory of alternative actions to stop the proposal. eg. write letters write to newspapers Raise money to protest Protest on site etc. Students asked to select and justify one or more alternative. Assessed on quality and objectivity of justification.
C. Acting on one's beliefs		
6. acting (one-off)	Organizing and leading a protest meeting to prevent a local cosmetic factory using live animals for tests	Observation schedule to record behaviour Plus An essay justifying the action taken in terms

	and experiments.	of the goals, rights and duties of the factory owners and of animal liberationists.
7. acting with a pattern, consistency and repetition	Join a small environmental committee for several months. Committee to act as a watchdog for the school to monitor community actions affecting the quality of the local environment.	Review of agendas and proposals by the committee to assess quality and consistency of values applied to proposals and to courses of action.

As has been advocated elsewhere in this volume (Part II) values clarification, whether involving the values of others or of personal values, does not aim to instil any particular value or set of values but to help individuals make rational decisions and to understand and appreciate personal and community values. Assessment procedure therefore should be especially sensitive to this aspect and should never demand a specific statement of a particular attitude or value, especially if such information is to be used for the purpose of grading.

The book Values Clarification by the American educator Sidney Simon and his colleagues probably remains the most widely known and used resource in the area of personal values (19). This volume describes almost 80 highly effective strategies and techniques to help individuals clarify their personal values. Many of these techniques could be adapted for the purpose of assessment. Almost all would be useful within the context of a programme of socially relevant biology. The methods include use of inventories of personally preferred activities; completion of values grids; voting procedures for choosing alternatives; rank order and rating procedures; forced choice situations; values surveys; interview techniques; projection methods and dozens of others. The book is highly recommended.

11.3 Conclusion

Technical difficulties associated with assessing aspects of attitudes interests and values for the purpose of grading, together with the widely held but extremely false view that science is value free or should be value free, have led to the relative neglect of the affective domain within programmes of school biology. This chapter has tried to show, however, that this in fact is a critically important and probably the most relevant of the three areas of cognitive, affective and psychomotor objectives within a programme of socially relevant biology.

What is needed is particular attention to the following aspects.

- Assessment should be concerned more with fostering the personal development of learners rather than simply grading their achievement.
- The affective aspects of personal development are at the heart of motivation and also lead to development of tolerance, willingness to clarify values and an empathetic and rational approach to the problems of day-to-day living.
- Assessment programmes in socially relevant courses, therefore, should focus on the long term development of transferable affective objectives especially those at the upper end of the Bloom team's hierarchy - namely valuing, the organization of values and the characterization of a values complex.
- A willingness to approach social problems rationally and scientifically is a key objective of this type of programme. Therefore the scientific attitude should be fostered through appropriate assessment methods and by other means. In particular the incorporation of a positive scientific attitude into the emerging values complex of each individual should be a central concern.
- The organization of values and the characterization of a values complex in an individual involve a systematic approach to the clarification of personal values. It is critical therefore that values clarification type learning activities, including assessment activities, are systematically presented to make this aspect of development totally overt.
- The analysis of social issues involving contrasted points of view usually involves an appreciation of the ethical systems and hence values of the various protagonists. This means that assessment of achievement in this area should include finding out how well students appreciate the goals, rights and duties, and hence the values, of all those involved.

Finally, in view of the central importance of affective objectives in a programme of socially relevant biology, it is reasonable to suggest that this domain should be dominant in any programme of assessment. Its main purposes would be to focus learning on the main thrust of the course as a whole and to provide data for individual educational guidance and counselling.

Notes and References

(1) Krathwohl, D.R. *et al*. *Taxonomy of Educational objectives; the Classification of Educational Goals: Handbook 2 Affective Domain*. New York: David McKay Co. 1956.

(2) *Ibid*.

(3) *Ibid*.

(4) *Ibid*.

(5) Some science educators argue against the idea that the scientific attitude exists as a single construct. See for example:

Elias, S.F. and Elias, J.W. "Curiosity and Open-Mindedness in Open and Traditional Classrooms" *Psychology in the Schools* Vol 13 1976 pp 226-232.

Gardner, P.L. "Science Curricula and Attitudes to Science" *The Australian Science Teachers Journal* Vol 21 No 2 1975 pp 23-40.

Hukens, A.A. *A Factorial Investigation of Measures of Achievement of Objectives in Science Teaching*. Ph.D. Thesis University of Alberta 1963.

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(6) Jones, B. "Measuring Students' Scientific Attitudes" *Science Education News* (NSW) Vol 31 No 4 1982 pp 25-32.

(7) Billeh, V.Y. and Zakhariades, G.A. "The Development and Application of a Scale for Measuring Scientific Attitudes" *Science Education* Vol 59 No 2 1975 pp 155-165.

(8) Kozlow, M.J. and Nay, M.A. "An Approach to Measuring Scientific Attitudes" *Science Education* Vol 60 1976 pp 147-172.

(9) Meyer, G. Rex "Talking Together" (A Test of the Scientific Attitude) from *A Test of Interests*. Milton, Queensland: The Jacaranda Press 1969.

(10) Mayer, William V. *Assessment: A Practical Guide to Improving the Quality and Scope of Assessment Instruments* (Science and Technology Education Document Series No 16). Paris: Unesco 1986.

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(12) Remmers, H.H. and Gage, N.L. *Educational Measurement and Evaluation* Revised Edition. New York: Harper and Brothers 1955.

(13) Likert, R. "A Technique for the Measurement of Attitudes" *Archives of Psychology* Vol 22 No 140 June 1932 pp 1-55.

(14) Osgood, C.E.; Succi, G.; and Tannenbaum, P. *The Measurement of Meaning*. Urbana Illinois: University of Illinois Press 1967.

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(16) Billeh, V.Y. and Zakhariades, G.A. "The Development and Application of a Scale for Measuring Scientific Attitudes" *Science Education* Vol 59 No 2 1975 pp 155-165.

(17) This approach is based on a procedure used by the Biological Curriculum Study (BSCS) in the United States.
See
McInerney, J.D. "Ethical Values in Biology Education" *in* Frazer, M.J. and Kornhauser, A. *Ethics and Social Responsibility in Science Education* (Science and Technology Education and Future Human Needs Volume 2). Oxford: Pergamon Press for the ICSU Press 1986 pp 175-181.

(18) Rath, Louis; Harmin, Merrill; and Simon, Sidney *Values and Teaching*. Columbus Ohio: Charles E. Merrill 1966.

(19) Simon, Sidney B.; Howe, Leland W.; and Kirschenbaum, Howard *Values Clarification A Handbook of Practical Strategies for Teachers and Students*. New York: Hart 1972.

Chapter 12

ASSESSING MANUAL SKILLS

12.1 Introduction

The hierarchy of educational objectives for the cognitive and affective domains as proposed by Benjamin Bloom and his colleagues were described in Chapters 10 and 11 respectively. This present chapter deals with the third of these domains, termed the psychomotor domain, which deals mainly with the development of manual skills. The Bloom team has also proposed a hierarchical scheme for this domain but the scheme has not been as widely accepted or applied as for the cognitive and affective areas (1). It nevertheless provides a useful general framework for assessment. The Bloom hierarchy begins with "imitation" and proceeds through higher levels of manual dexterity, namely "manipulation", "precision" and "articulation" to the highest level of "naturalisation" (2).

Within a more conventional programme of school biology the achievement and assessment of manual skills is usually restricted to laboratory activities including ecological field studies (3). Activities involving the assessment of manual skills usually include handling glassware and chemicals; manipulating measuring instruments; using optical instruments such as a hand lens and a microscope; skills associated with collecting, handling and keeping live animals and plants; observational, measuring and recording skills; skills associated with preparing plant and animal specimens for observation including dissection, display of organ systems and the preparation of stained tissues; the preparation and maintenance of collections such as herbaria or insect collections, and so on (4).

Laboratory activities, however, inevitably involve cognitive and affective as well as psychomotor elements. In most programmes of assessment it is the former rather than the manual elements which are given greatest emphasis. Most science educators see the purpose of laboratory work in terms of explicating the processes of scientific discovery. It is the intellectual processes of experimental design, the recording and description of results and the interpretation of results which are given most weight. Sometimes attention is given to affective outcomes such as willingness to participate, persistence or degree of interest expressed.

Separate educational diagnosis and counselling in the three domains becomes difficult because of blurring across the various types of outcomes. Instead of assessing achievements in the three domains separately, often the emphasis is on the quality of a single "result". Use of the microscope is a clear example. Frequently students are assessed on the quality of a labelled drawing of an observed specimen. This gives weight to two cognitive aspects, namely knowledge of the overall use of the microscope and knowledge of the characteristics of the specimen. Assumptions are made that if the quality of the product is satisfactory then the enabling knowledge skills and attitudinal elements such as which power to use, adjustment of the focus, use of the lamp and willingness to persist until results are achieved are also satisfactory. But the quality of achieving these enabling steps may vary greatly from student to student and should be separately assessed.

Part of the confusion is that many teachers see the unit of assessment in laboratory work to be the activities as a whole rather than their components. This is because their aim is to achieve higher order outcomes such as developing an awareness of what scientists do to make discoveries. This higher order focus is understandably very important, but so too are the more specific aspects. Because of the "holistic" approach to laboratory work it is sometimes seen to be something "apart" from the rest of the course. In so-called theory learning each cognitive step is thoroughly explored and assessed but since the assessment in the laboratory is often not like that, students tend to perceive it differently and not as only one of a series of learning activities contributing to achieving the overall course objectives.

The development of manual skills in their own right is an important aspect of personal development. It is self evident that all citizens require manual skills in almost all aspects of daily living - walking, running, playing sport, performing household duties, earning a living. All have psychomotor components and all teachers in all subjects at all levels have responsibility for fostering and promoting general transferable skills. This implies that in any assessment programme the manual outcomes need to be carefully identified, characterized and assessed.

In a socially relevant biology course manual skills have especially important roles and should therefore be a key part of the programme of assessment. They are not just limited to the methods of science but have much broader applications. The activities in a socially oriented biology programme have a different orientation from conventional biology. Instead of focusing on the scientific aspects alone the focus is also on social issues. Scientific techniques remain important but have a different role. Tests of foodstuffs are undertaken to explore nutritional values and to check for additives; chemical analysis is performed to check on the degree and nature of possible environmental pollution; ecological observations are made of plants and animals to check on distribution and abundance in areas of potential environmental degradation; tissues are prepared and examined to study the influence of toxic substances; physiological experiments are performed on plants to check on the effect of pesticides, and so on. Laboratory work becomes just one form of strategy for investigating a social problem or issue. Many of these activities have a high loading of manual skill and these manual components should be identified, directly developed and overtly assessed.

Apart from these science type laboratory activities, a socially oriented biology programme provides a framework for developing and assessing a wider repertoire of manual skills. These include skills associated with general physical wellbeing and prowess; skills associated with the home such as food preparation; vocational type skills, and a more complex range of skills for observing and recording phenomena such as social survey techniques.

Laboratory and other forms of practical activity become fully integrated into the structure and teaching sequence. Cognitive, affective and psychomotor elements become closely integrated in the development of the whole person. It is important, however, for the purposes of educational counselling and guidance that they be separately assessed so that strengths in one domain may be utilized to help overcome weaknesses in another.

12.2 Principles and Procedures

(a) Assessing General Psychomotor Objectives

The psychomotor hierarchy of educational objectives developed by the team of psychologists working under the leadership of Benjamin Bloom provides a useful framework for the assessment of achievement of manual skills (5). There is, however, some difficulty in applying such a system to an academic subject, even a science subject such as biology. In the case of many vocational areas such as plumbing, carpentry, engineering and surgery, the types of manual skills and the level of achievement required is fairly clearly defined. In a subject like biology the range of skills is more diffuse and proficiency may not need to be as rigorous as in specialized vocations. This is especially the case in programmes of socially relevant biology where an even broader range of manual skills is involved and where only general levels of proficiency may need to be developed.

This aspect should be carefully considered when assessing achievement of manual skills. Some skills, for example, the handling of certain specialized equipment for chemical analysis in the field, may only be needed at the level of imitation, whereas other skills, such as use of the microscope, may be needed at the level of articulation or even of naturalization.

Another aspect of applying the Bloom hierarchy of psychomotor objectives involves the issue of mastery. Some manual skills may need to be developed to, say, the level of precision - for example the mounting of tissues on a microscope slide. If this is the case criterion referenced testing involving mastery criteria may be necessary. If, on the other hand, the concern is to place the students in rank order on the basis of some output at the level of articulation such as a photographic display or a museum collection, then normative methods involving letter or percentage grades should be used.

The following table lists the five levels of psychomotor (manual) objectives proposed by the Bloom team (6). Examples are provided of the types of outcomes and assessment procedures that could be required in both a conventional and a socially oriented biology course.

Assessing Psychomotor (Manual) Objectives for Conventional and for Socially Oriented Biology

Psychomotor (Manual) Objective	Example of Outcome and its Assessment	
	(A) Conventional Biology	(B) Socially Oriented Biology
1. Imitation Copy of an observed manual act but lacking neuromuscular coordination.	Student follows and repeats teacher demonstration on use of dissecting scissors in opening the body cavity of a dogfish. Assessment Checklist of steps. Student ticks each step as it has been completed.	Student follows and repeats demonstration by teacher on use of a tape recorder to record social survey interviews. Assessment Teacher checks off correct steps as task is performed by student.
2. Manipulation Copy of an observed manual act usually following instruction, displaying some neuromuscular coordination.	After teacher demonstration, student follows step by step written instructions (with illustrations) to open and display the body cavity of a dogfish. Assessment Checklist of steps. Each step checked as completed. Each step rated for quality of work (percentage or letter grade) - self, peer or teacher rating.	Teacher demonstrates procedures for preparing a display of posters and photographs recording key situations relevant to a social issue and then students, working in groups, prepare their own display. Assessment Using an observational checklist teacher rates student performance on (i) cooperative manual activity (ii) quality of manual skill (iii) quality of final product.
3. Precision Performance of manual task with accuracy,	Performance of chemical tests to check composition of food.	Students take colour photographs and review points of an environmental situation which

proportion and exactness.	Assessment Observation rating scale to rate degree of competence in handling glassware and chemicals. Plus letter or percentage grading of accuracy of results.	is the centre of community conflict and concern. Assessment Observational ratings of manual skills in using camera and letter grade rating on quality of final photographs.
4. Articulation Competent performance of a manual task involving coordination of a series of other acts.	Setting up a microscope to examine a prepared slide of a stained cross section of a plant stem. Assessment Observation checklist for teacher to rate (i) sequencing of steps (ii) degree of accuracy in each step (iii) general proficiency and (iv) final outcome.	Preparing of a report portfolio involving newspaper clippings, photographs, written reports, interview transcripts and so on. Assessment Assessment by teacher using a rating checklist on qualities of the product - neatness, coverage, layout, visual impact and so on.
5. Naturalization Routinization of a manual task to the extent that it becomes an automatic, spontaneous and (ultimately) a subconscious response.	Speedy, proficient and accurate use of a direct weighing balance to weigh a range of objects such as soil, dry chemicals, liquids, live organisms, plant tissue and so on. Assessment Observation checklist for teacher to rate speed, proficiency and precision, plus Yes/No mastery assessment of final outcomes.	Student committee to take responsibility for designing and regularly maintaining a weekly current affairs bulletin board with attractive visual displays. Assessment Weekly ratings by (i) members of the committee, (ii) peers and (iii) teacher on layout and general effectiveness of the display - group assessment of the work of the committee.

In the above table the dichotomy between columns (A) conventional biology and column (B) socially oriented biology breaks down in respect to the latter since many of the manual skills required for conventional biology are also required to investigate the scientific aspects of social issues - eg. chemical analysis of pollutants; examination of microorganisms; dissections to check on food habits of organisms and so on. Development of the skills in column (B) is however less likely for students in more conventional programmes. The types of manual skills involved in the social issues aspects would be at two levels - the investigatory level and the reporting and presentation level. Many of the investigatory skills would involve conventional laboratory tasks whereas the presentation skills would be mainly in the preparation of displays and illustrated reports, and would therefore have a high audio-visual component.

(b) Techniques for Assessing Manual Skills

As outlined in the introduction to this chapter most science educators downgrade the role of manual skills per se and tend instead to view laboratory and field work in biology more broadly, mixing in cognitive, affective and psychomotor elements in assessing outcomes - frequently the emphasis is on intellectual (cognitive) aspects such as design of experiments or interpretation of data. If, however, the development of manual skills is seen to be an important outcome of science teaching then there is available a range of measurement techniques for this purpose. Most are based on observational schedules involving checklists and rating scales.

One important aspect of the assessment of manual skills is the need to distinguish between "procedure" and "product". Assessment can focus on the quality of manual actions during the step-by-step performance of a task or it can evaluate a finished product or final outcome. In some cases both procedure and outcome can be included in an assessment activity. The following example describes a technique for assessing the manual procedures involved in a chemical analysis of nutrients - it involves evaluation of both procedure and product.

Example: Assessment of Practical Activity - the Chemical Analysis of Nutrients

Source: Mayer, William V. Assessment: A Practical Guide to Improving the Quality and Scope of Assessment Instruments (Science and Technology Education Document Series No 16). Paris: Unesco 1986 pp 193-197

The following investigation is a model of how laboratory activities can be assessed. It includes a student rating sheet and an explanation of the ratings together with suggested unknowns for which the student will be tested. Protein can be measured by the biuret test. The iodine test will measure the presence of starch. A commercial product such as "Tes-tape" or Benedict's solution can be used to measure the presence of glucose. Indophenol provides a test for vitamin C, silver nitrate one for chloride ions. The paper test for fat is sufficient for this investigation which is qualitative not quantitative. This material is included primarily to suggest ways of record keeping for a laboratory assessment. Such records can easily be adapted to other laboratory practical situations.

An effective way to evaluate laboratory skills is to have students analyze unknown samples for their nutritive components. One to two laboratory periods should be allowed for this; the length of time depending upon the group of students involved and the length of the laboratory periods. Students should be allowed to use their textbooks for test procedures or be provided with worksheets of these procedures. It is recommended that each student be evaluated on two unknowns, one simple (1-2 components) and one more complex (3-4 components). At the beginning of the laboratory period each student should be given 25-30 ml. of an unknown sample. When analysis is completed to the student's satisfaction, the student is ready for the more complex unknown. If the analysis is incorrect, the student should repeat his tests. A maximum of three such trials is suggested. Should a third trial be necessary, the teacher should observe the student to see if his or her errors are generated through misunderstanding of some aspect of the problem. If this is the case, these misunderstandings should be rectified before the student makes his final interpretation of this first unknown.

The following check list sheet is recommended for evaluating the students; ratings given the student are to be circled. Prepare a check sheet for each student to be given to him at the completion of the activity. Explain to the students the criteria on which they are being rated. Note that laboratory technique and method of approaching the problem, as well as correct analysis, are considered important.

Student's name ______________ Unknown sample numbers __________

CRITERION	RATING								
1. Carefulness in procedure			1			2			3
2. Organizational approach			1			2			3
3. Trials to correct analysis			1			2			3
4. Interpretation									
4a Sample A	0		1		2		3		4
4b Sample B	0	1	2	3	4	5	6	7	8
Total									

Comments:

1. A 3 rating indicates that the student:

   -- treats chemicals (including the unknown) with care and respect
   -- measures carefully
   -- rinses measuring implements thoroughly between tests
   -- follows directions carefully

A 2 rating indicates that students are proficient in at least two of the above.

A 1 rating indicates that the student needs much practice in laboratory procedures.

2. A 3 rating indicates that the student can:

   -- identify the task
   -- set up some sort of chart showing his results
   -- proceed with the analysis in an orderly fashion
   -- identify and correct (probably through repetition of a test) his mistakes

   A 2 rating indicates that the student needs help with one or two of the above.

   A 1 rating indicates that the student needs much help from teacher or peers in performing the analysis.

3. A 3 rating indicates that the student made the correct analysis on the first trial.

   A 2 rating indicates that the student made the correct analysis on the second trial.

   A 1 rating is given on the third trial regardless of correctness.

Criterion 4. Below is the scale recommended for use in scoring the analyses.

4a	Correct analysis	4
	All components correct except one	2
	No correct components	0
4b	Correct analysis	8
	All components correct except one	6
	All components correct except two	4
	All components correct except three	2
	No correct components	0

When there are incorrect as well as correct components, subtract ½ point from the indicated rating for each incorrect component. For example, in series 4b a student's final analysis shows all components correct except one, plus one incorrect component. All components correct except one is a 6 rating. Subtracting ½ point for the incorrect component gives this student a 5½ rating.

Preparing the Unknowns

In making up solutions, starch, sugar, chloride salts, and vitamin C are all water soluble. Cooking oil or other liquid fat as well as raw or powdered eggwhite (protein) can be mixed with these although they are not totally miscible. Whole milk contains protein, fat, sugar, and usually vitamin C; skim milk contains protein, sugar, usually vitamin C and a trace of fat. A paste may be made of lard or vegetable shortening plus cornstarch and/or powdered sugar and/or eggwhite, etc.

In preparing the unknowns provide at least 50-60 ml. of solution (or a comparable amount of paste or mixture) per student to allow for accidents and repetition of tests. For a class of 20 students 5-6 different unknowns for series A and 5-6 for series B should be provided.

The following example is a simple test of procedure only.

Example: *Preparing and mounting a section of stained plant stem for observation under the microscope*

Source: *Suggestion by author.*

Students are given the following items.

(i) Slide and cover slip
(ii) Forceps and needles, camel hair brush
(iii) 2 cm length of plant stem
(iv) protected edge razor blade
(v) filter paper
(vi) mounting fluid
(vii) liquid plant dye

They are asked to prepare a transverse section of the stem and stain and mount it for observation under a microscope.

Teacher observes procedure and checks that each step has been performed according to the following criteria. Each criterion to be rated 0 or 1.

1. Correct procedure followed
2. Step in correct sequence
3. Technique neat and tidy
4. Materials and equipment handled with facility and not clumsily
5. Step satisfactorily completed

Steps could include:

1. Slicing stem
2. Cleaning slide and cover slip
3. Adding mounting fluid
4. Transfering section to slide
5. Mounting specimen
6. Covering with cover slip
7. Irrigating with dye
8. Tidying final product.

The next example focuses only on product.

Example: *Hand lens examination of simple biological specimen and recording of observation in the form of an unlabelled outline drawing*

Source: *Suggestion by author*

Students are given a hand lens, unknown biological specimen and pencil and paper. They are required to examine the specimen and prepare a drawing.

Specimen could be a part of small plant (eg. moss), the wing or leg of an insect or any other object requiring about 10x magnification to observe structures.

Drawing could be rated out of five with 0 or 1 being assigned for qualities such as the following.

1. Accuracy of several shapes and proportions
2. Sharpness of pencil lines
3. Indication of scale
4. Representation of biological structures
5. Delineation and resolution of those details not clearly visible to the naked eye.

The above examples focus on the scientific aspects of an activity but it should be remembered that in a socially oriented biology programme these types of activities are means to an end and not ends in themselves.

Another aspect of assessing the performance of manual skills is to decide whether the course as a whole involves a core of skills which need to be "mastered" by all students. If there is such a core of skills then criterion referenced methods should be employed for their assessment (7) and the tasks to be mastered should be carefully identified and defined in terms of a standard of performance. The standards could either be tightly defined in terms of effectiveness and appropriateness of procedures and quality of outcome or else could be left fairly open and expressed in terms such as "at a standard demonstrated to the satisfaction of the teacher". Frequently this type of approach is presented to the students somewhat like a learning contract.

Example: *Checklist of manual skills to be mastered in a programme of socially relevant biology (Illustrative items only)*

Source: *Suggestion by author*

Instruction to Student: At the conclusion of the course you should be able to perform the following practical tasks. As you become confident that you can perform each of the tasks to the standard described in your practical manual, demonstrate the task to your teacher and have it checked off the list. All items should be checked by the end of the course.

Task	Date Satisfactorily Demonstrated
1. Chemical Tasks	
Use direct weighing balance	______
Perform chemical tests to identify unknown nutrients	______
Measure the pH of soil	______
etc.	______
2. Observation of Live Specimens	
Prepare portfolio of 20 drawings from nature	______
Take and present 10 photographs of plant communities	______
3. Use of the Microscope	
Set up the microscope for:	
(i) low power dry mounts	
(ii) low power wet mounts	______
(iii) high power dry mounts	______
(iv) high power wet mounts	______
etc.	______
4. Ecological Techniques	
Prepare a soil profile	______
Draw the profile of a forest	______
Draw a transect across a small stream	______
etc.	
5. Preserving and Displaying Organisms	
Collect 50 representative plant specimens and prepare an herbarium	______
Collect and display 20 insects	______
Collect and display 10 shells	______
etc.	
6. Use Audiovisual Equipment	
Use a hand lens to study and draw five named objects	______
Use a 35mm slide projector	______
Set up and use an overhead projector	______

Set up and use a video tape recorder . . . . . ______
Tape and present a 10 minute audio programme . . . . ______
etc.

7. Oral Communication

Give a 10 minute talk to the class . . . . . . ______
Take part in a debate . . . . ______
Interview members of the community . . . . . . ______
etc.

8. Recording Case Studies of Social Issues

Prepare a current affairs bulletin board . . . ______
Prepare a file of newspaper clippings on a defined issue . . . . ______
Prepare a portfolio of photographs and drawings illustrating a case study . . . . ______

Other categories could include computer skills; general manual dexterity skills; social survey skills; home management skills; craft skills; vocational skills; photographic skills and so on. Such a mastery list should of course reflect the objectives of the course and all items should be realistic and attainable. Students should be given as many opportunities as possible to reach the required standards and should be allowed to "present" at any time during the course.

An important advantage of task inventories of the type presented above is that they can assess at defined levels of the Bloom hierarchy of psychomotor achievement - imitation, manipulation, precision, articulation and naturalization. In fact the proportions of these "levels" of achievement within the total inventory can be determined according to need. A carefully structured programme to develop manual skills, therefore, can be designed and monitored.

(c) The "Three Domain" Approach

As previously discussed most science teachers view laboratory and field activities holistically and usually do not separately assess manual, cognitive or affective outcomes. For example the following test situation has been described by the well known biology educators P. Tamir and I. Glassman (8). It assesses two of the domains - psychomotor and cognitive - requiring both manipulative and interpretative skills.

Osmotic Behaviour of Cells*

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* Tamir, P. and Glassman, I. "A Practical Examination for BSCS Students" Journal of Research in Science Teaching Vol 7 Issue 2.

SKILLS AND ABILITIES TO BE TESTED

(a) Preparation of a temporary slide;
(b) Performance of experimental operations which require observation with a microscope and the recognition and evaluation of phenomena.
(c) Repetition of measurements and observations to collect a set of reliable data;
(d) Logical progress from one step to the next;
(e) Compilation of clear and meaningful results;
(f) Prediction of experimental results;
(g) -Formulation of hypotheses and the drawing of conclusions and inferences from experimental data.

TOPIC AREA: The Osmotic Behaviour of Cells—phenomena of plasmolysis and deplasmolysis.

APPARATUS: (For each student)
Microscope, microscope slides, coverslips, scalpel, forceps, onion, strips of filter paper, solutions labelled 'A' and 'B'.

'A' is a solution of 0.25% fuchsin in 20% sodium chloride.
'B' is a solution of 0.25% fuchsin in distilled water.

Student Instruction Sheet:

STUDENT INSTRUCTION SHEET: TIME: 1 HOUR

Allocation of marks	INSTRUCTIONS
15	1. Peel off a piece of epidermis from an inner leaf of the onion. Prepare a slide for microscope observation in a drop of solution "B".
	2. Examine your slide under the microscope and choose an area where you can see one layer of cells in which the nuclei may be clearly observed.
10	3. Add a drop of solution "A" on one side of the cover slip and draw it under the slip with the aid of a piece of filter paper—while doing so, observe what occurs under the microscope. Continue to add solution "A" until you observe some change.
10	4. Describe what occurs.
10	5. Now add a drop of solution "B" in the same way until you observe some change under the microscope.
	6. Describe what occurs.
15	7. Report your observations in such a way that the reader will obtain a clear picture of what occurs in different stages of the experiment. Call the examiner and show him your report.
10	8. How would you explain the phenomena observed?
7	9. What is *your* hypothesis regarding the difference between solutions "A" and "B"? Explain.
7	10. Can you conclude, on the basis of your experiment, that the concentration of the sap in the onion cells equals that of solution "B"? Explain.
7	11. What results would you expect to have found had you used red blood cells instead of onion cells? Explain.
9	12. What differences between animal and plant cells affect the behaviours of these cells in experiments such as you have performed?

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Check List for Examiner:

1. Watch for clear work. (Does the student overflood the slide?) (Are there bubbles which interfere with observations?)
2. Watch how the student handles the microscope.
3. The best way to report what occurs in the various steps is by drawing. In Item 7, the student is asked to show his report. If there is not a drawing, subtract five marks unless the description is unusually accurate.
4. In reporting, the student should use correctly the names of the parts of the cell.
5. In Item 10, a negative answer is expected.
6. In Item 11, the student has to deal with the behaviour of the red blood cell under the influence of solution 'A' as well as solution 'B'.
7. In Item 12, the student should mention cell wall, cell membrane, vacuole and cytoplasm.
8. If the term plasmolysis does not appear in his report subtract five marks.

The advantages of this type of assessment are as follows:

1. The cognitive significance of the manual manipulations are made overt.

2. One grade (score) could be given to the activity as a whole.

3. It would be relatively easy to take out separate scores for the purely manual and purely cognitive components.

There are, however, several disadvantages. These are:

1. The weighting between manual and cognitive components appears to be arbitrary - with by far the greater emphasis being given to cognitive aspects.

2. It is not easy to see the levels of achievement required especially in the psychomotor area. Does the activity involve more than imitation and manipulation? If so what are the criteria for assessing the degree of precision, articulation or naturalization?

3. There is no provision for the assessment of attitudes.

Nevertheless this type of "omnibus" approach to assessment of laboratory activities is popular and useful and would be especially valuable if assessment activities were constructed so that weightings required for the three domains could be identified. The absence of affective assessment in such an omnibus approach can be overcome by adding an appropriate observational rating inventory by which the teacher observes each student performing the activity and grades (rates) behavioural indicators of attitude. Such behavioural indicators might include the following:

Displays initiative
Persists with the task
Works independently

Works steadily
Seeks alternative solutions
Appears interested
Appears confident

And so on.

Laboratory "activities" can thus become assessment devices across all three domains and with careful design can assess at defined levels of each domain. If this approach is adopted, however, close attention must be given to the purpose of the various components of the assessment - in particular those elements to be used for grading must be carefully demarcated. Students should clearly understand the purpose of each aspect of the assessment procedure and what use will be made of the data obtained.

There is another important point. In socially oriented biology the assessment activities should be seen to link to some social issue and should not be given as isolated tasks. The example given above on osmosis, for instance, would have little justification in a programme of socially relevant biology unless it in some way illuminated how scientific processes are useful investigatory tools for analysing aspects of societal problems. This example could perhaps be linked to environmental (pollutant) problems or to medical applications involving blood cells.

12.3 Conclusion

Assessment of manual skills within programmes of school biology has been the least well represented of the three domains of educational objectives - cognitive, affective and psychomotor. Also technical aspects of the assessment methods have been inadequate in many cases. This has been brought about because of the following.

1. Not all science teachers perceive the development of manual skills to be as important or educationally significant as the achievement of cognitive or affective outcomes.

2. The work of Bloom's team on developing a hierarchy of educational objectives in the psychomotor domain is perhaps not as widely known or applied as for the other domains. Therefore levels of achievement in the psychomotor domain are frequently undefined.

3. The unit of assessment has tended to be the "laboratory activity" and cognitive, affective and psychomotor outcomes have not always been clearly demarcated.

4. The cognitive aspects of practical work have been given the greatest attention.

5. It is difficult to test achievement of manual skills reliably and validly in public examinations and this has tended to

contribute to their neglect within programmes of continuous assessment.

These problems need to be addressed if the development of manual skills is to become a significant component of school biology. Manual skills are probably the most transferable of all educational outcomes and so they have an important role in programmes of socially relevant biology. What must be appreciated, however, is that the manual (and indeed the cognitive and affective) components of laboratory activities in socially relevant biology have a service role rather than a role in their own right. They are the scientific tools needed to investigate social issues and to resolve social problems.

Notes and References

(1) Dave, R.H. Taxonomy of Educational Objectives and Achievement Testing: Developments in Educational Testing: Proceedings of the International Conference of Educational Measurement, Volume 2. London: University of London Press 1967

(2) Ibid

(3) Mayer, William V. Assessment: A Practical Guide to Improving the Quality and Scope of Assessment Instruments (Science and Technology Education Document Series No 16). Paris: Unesco 1986

(4) Doran, Rodney L. Basic Measurement and Evaluation of Science Instruction. Washington DC: National Science Teachers Association 1980

(5) Dave, R.H. op.cit. Note 1

(6) Ibid

(7) See for example Popham, James W. (Ed) Criterion-Referenced Measurement an Introduction. Englewood Cliffs: Educational Technology Publications 1971 108 pp

(8) Tamir, P. and Glassman, I. cited in Queensland Department of Education School Assessment Procedures 3 Assessment in Science. Brisbane: Research and Curriculum Branch Queensland Department of Education 1971 pp 43-44

Chapter 13

THE ISSUE OF PUBLIC EXAMINATIONS

13.1 Introduction: The Role of Public Examinations

The public examination is powerfully influential in almost all school systems of the world (1). Very few countries - Australia is a notable exception - have a deliberate policy of minimizing or of totally abolishing formal public examinations. In some countries such examinations occur on several rungs of the educational ladder - lower primary, upper primary, junior secondary, upper secondary and tertiary entrance. In some they so dominate the educational system that they can be seen to be the main factors in determining the total pattern of schooling. In Japan they have become so all pervasive and inimical that the term "examination hell" has become part of popular parlance. While not all school systems have to contend with such an extreme situation the selective public examination does pose many difficulties for educators and some of these are considered below. Partial solutions are presented to moderate negative aspects.

By "public" examinations is meant an examination set (and usually administered) by a central authority such as a ministry of education or an examinations board, and standardized for all schools of a particular educational system. Such examinations traditionally have several roles.

The first of these is selection for entry to higher grades in which places are restricted and competitive. This is an especially important role in school systems where educational places are available to relatively small percentages of the school age population - especially in the highest grades. In some school systems one of the most important barriers is selection for a few highly competitive places in the secondary schools. Economic constraints frequently make universal secondary education impossible and a place in a secondary school must be reserved for only the most able. This imposes a great responsibility on the examiners and fails to take sufficient account of late developers.

In many school systems, however, this problem is alleviated, at least to some extent, by the development of non-formal education. Thailand, for example, has an especially effective non-formal programme (2). Non-formal education is concerned with programmes for adults who have been forced to leave school before gaining any formal qualifications, and in particular it caters for those who have in the past missed a place in the formal secondary school. It provides catch-up programmes, usually given by evening colleges, and prepares adults for examinations at specified levels of the educational system.

A second role for public examinations is to select for excellence. Usually this is for the award of prizes of scholarships. While this is a minor role it is important in promoting excellence and in giving opportunities for continued schooling to the most able pupils who might otherwise have to leave school.

Both these roles depend on a normative form of examination. That is candidates are ranked in order of achievement and selected on the basis of comparative performance.

The third role for public examinations depends on criterion-referenced rather than normative standards (3). This role is to check on the mastery of specified skills or an area of knowledge. The standard is the achievement of a stated set of carefully defined objectives and not the position of an individual on a ranked list. Such mastery examinations are being used with increasing frequency to define minimum standard of competency at specified levels of the educational system - especially in basic areas such as language and numeracy. Selection in such instances depends on both demonstrated competency over a range of objectives plus position on a ranked list determined by additional normative tests.

Examinations in biology may have selective and/or competency roles. It is, however, important for examiners to understand the differences between the two and to set appropriate test items for each. Normative test items must be deliberately designed to "spread" the candidates with specified proportions of questions having specified levels of difficulty so that only the best students get high marks. Criterion-referenced tests on the other hand should only be concerned with checking whether or not a defined standard has been attained and the percentages attaining that standard are not the main issue. A multiple choice question in genetics for a normative examination should provide "distractors" which build in anticipated errors in logic or arithmetic so as to sort out various levels of understanding. A criterion-referenced test should be concerned only with whether or not a candidate can successfully complete one highly specified task such as calculating the percentage of a particular type of offspring from a specified genetical cross.

The introduction of mastery tests as a component of public examinations has been helpful in improving the effectiveness of such examinations. They ensure that not only does the best group of students proceed to the next level but that all successful candidates attain minimally acceptable standards in essential components of any educational programme.

In programmes of socially oriented biology the selective and mastery testing rules for public examinations apply just as in any other type of biology programme. What is different, however, is the focus of the examination on more general selective criteria than would be the case for more conventional programmes. In conventional courses the main purpose is to prepare students for further studies in biology and to select those who are adequately prepared for such study. If mastery elements are included these are concerned with testing defined standards of achievement in the understanding of biological concepts and in performing a range of science-type laboratory skills. A socially oriented programme too may have that role but it is also concerned with checking on whether students can usefully and appropriately apply what they have learnt to their everyday lives, to analysing social issues and to resolving social problems.

This focus of attention implies that an examination in a socially oriented programme should be based on both scientific and socially oriented objectives. The stimulus material used for the test questions should call for the interpretation of biology-based social issues and problems and not only on academic biological concepts and procedures.

13.2 Influence on the Curriculum

The main problem about public examinations is that the specifications for any given examination almost always determine exactly what is taught in the classroom. Teachers teach for passing the examination and neglect topics unlikely to be included on the examination paper.

This problem is especially worrying in cases where the examination is itself based on outdated content and this all too frequently occurs in conservative school systems, especially in biology. Some systems still retain formal programmes and examinations in academic botany and zoology (see Chapter 3). These courses frequently stress classification, structure and life histories of specified plants and animals and rely almost entirely on memory work. Modern aspects such as ecology and genetics are given low priority and the social relevance issue is frequently ignored altogether. Problem-solving skills are not encouraged. Even in programmes which integrate botany and zoology into a more modern biological framework social issues are frequently omitted and memory work is the order of the day.

In such situations students who must face intensive competition at a selective examination cannot afford to follow their own interests, and teachers are unable to foster individuality. Convergent "cramming" to get the highest possible mark in the examination becomes the central objective.

An even worse situation occurs when examiners fall into a routine, tending to set similar or even identical questions from year to year. Passing the examination becomes the "art" of trying to predict and "out-guess" the examiner and students become "examination-wise" instead of "discipline-wise".

Conversely of course well constructed and well organized examinations can have a positive effect on the curriculum. If examiners set questions which probe at the skills of problem-solving this aspect will be emphasized in the classroom. If they base questions on the interpretation of previously "unseen" stimulus material then it is not possible for students or teachers to out guess them. If they stress issues of social relevance and set questions based, say, on recent newspaper articles, these aspects will be stressed in the classroom.

It is important, therefore, for examiners to recognize the influence of examinations on the content and methodology of classroom teaching and to ensure that their influence is positive and does not inhibit innovation and achievement of meaningful educational outcomes. One thing is clear, specifications for the examination and the types of questions set should be continually revised to prevent prepared answers and to ensure that the coverage is up-to-date in terms of biology, societal issues and problems and pedagogy.

13.3 Range of Objectives Tested

Examinations can only test the achievement of a relatively narrow range of educational objectives. Unfortunately all too many rely most heavily on memory work, neglecting tests of achievement for thinking and interpretative skills such as application, analysis, synthesis and evaluation. These higher mental processes can be tested effectively by the use of appropriate test items but unfortunately other important areas such as attitudes, interests, values, and certain practical skills are virtually impossible to test validly in a public examination.

This inevitably narrows the type of outcomes stressed in the classroom. Teachers develop only those attributes that will be tested by the examination. In particular, development of attitudes and interests is neglected because affective outcomes are difficult to test by means of a paper and pencil test (Chapter 11).

A solution to this problem which is finding increased favour in many school systems is to set aside a proportion of the marks for areas which cannot be tested by a written paper. Assessment for this component is based on ratings determined by the school, usually devised from observation of behaviour and/or the performance of assigned tasks in the laboratory or in the field (refer to Chapters 10-12). There are of course problems associated with honesty, with uniformity of standards and with validity of the test procedures. The problem of potential dishonesty by a teacher over-anxious to favour his or her own students can be overcome by an inspectorial system and by inter-school moderation. Uniformity of standards for a normative type of approach can also be achieved by inter-school moderations but difficulties are reduced if criterion-referenced methods are used based on uniformally defined standards. Mastery methods help also to overcome problems of validity provided the standards are uniformally defined.

In socially relevant biology, as we have seen, issues involving attitudes and values are of central importance and therefore the affective area should be a main focus of any system of selective examining. As affective assessment is technically difficult to test objectively (Chapter 11) some kind of rating scheme or attitude inventory may be most appropriate and that should be part of a continuous assessment system (Chapter 9) rather than of a terminal examination paper.

13.4 Practical Examinations

Practical tests as components of formal public examinations in biology present special problems. All too frequently they focus on a narrow range of practical skills such as the dissection of a rabbit or the performance of simple food tests. It is almost impossible for candidates not to predict what will be on the examination papers and therefore they concentrate on this narrow range of skills at the exclusion of the others. In particular, the skills of field work are badly neglected.

A second problem concerns the validity of such tests. In some cases evidence of performance is obtained indirectly for example from a labelled drawing of a dissection rather than from the dissection itself. There cannot be any direct observation of performance of a manual skill except by an on-the-spot superviser and this raises questions about standardization and potential bias. As discussed in Chapter 12 there is also the problem that cognitive and affective aspects of practical tests are frequently confounded with manual aspects and the validity of some items can be challenged on these grounds.

There are two partial solutions to these problems. They are not mutually exclusive alternatives. Both approaches could be used. The first is to employ a mastery approach using criterion-referenced methods assessed by the school and moderated by inter-school supervision. A manual skills inventory of the type described in Chapter 12 would be appropriate for this purpose. A pass in the examination would thus be conditional on mastery of a broad range of practical skills not just the narrow range tested by conventional biology practical examinations.

Some school systems require evidence that a comprehensive programme of practical tasks has been completed. This can be achieved by certifying achievement of a list of agreed practical skills; by requiring submission of special project reports or by inspection of practical notebooks. Validity of these procedures may be checked by random visits by inspectors or other officials especially appointed by the examination authority.

The second solution is to include questions in the written examinations which test skills in interpreting data from experimental work, in describing and explaining and critiquing practical procedures and in designing experiments and other practical activities. The following example illustrates this approach.

Example: Examination question on photosynthesis

Source: Modified from Mayer, William V. Assessment: A Practical Guide to Improving the Quality and Scope of Assessment Instruments (Science and Technology Education Document Series No 16). Paris: Unesco 1986 pp 199-200.

Stimulus Material

Photograph of three beakers of carbonated water with funnels inverted over Elodea and with water filled calibrated test tubes inverted over the funnel stem. Labels show the following: Beaker 1 was placed in direct sunlight. Beaker 2 was set up about one metre from Beaker 1 and is not in direct light. Beaker 3 is in a box to exclude light.

Questions

The student is asked to view the experimental set up and to respond to the following problems.

1. What one biological problem can be investigated with this set up?
2. What experimental variables must be controlled to solve the problem?
3. What assumptions do you have to make in order to solve the problem?

Evaluating the Response

The teacher will have the following items in mind to evaluate student responses.

1. At least two problems are possible: (A) Is light necessary for photosynthesis? and (b) Does the amount of light affect the rate of photosynthesis? Recognition should be given to such creative problems as Are all the plants alive? For the latter, the procedures the student proposes will be of great interest.
2. For the first problem example the experimental variable is light. The variable to be controlled is temperature. For the second problem, the amount of light is the experimental variable. Temperature, amount of carbon dioxide in the water, and biomass must be controlled.
3. For the first problem the assumptions are that the plants are alive and healthy, there's enough dissolved carbon dioxide to support photosynthesis, and the water temperature is within the range in which photosynthesis occurs. For the second problem the assumptions are that the plants are alive and equally healthy. Stable and similar water temperatures and active equivalent biomasses may be assumed.

This approach, however, is not a valid test of achievement of practical skills since there are no manual skills involved. It is essentially a cognitive test but some indirect evidence can be obtained of both attitudinal and manual skills. On the attitudinal side a correct response suggests that the student appreciates the scientific attitude. On the psychomotor side the evidence is even more indirect since it assumes that if a candidate can recognize the photographed objects he or she is likely to have seen them and would probably have handled and manipulated them. It would not be valid, however, to try to differentiate between the cognitive, affective and psychomotor domains by this form of test item and only a cognitive score should be recorded.

The other problem with this type of approach within a programme of socially relevant biology is that it tests the science only and not social application. This problem could be resolved in the case of the above example by substituting or adding questions such as:

- Suggest a situation where a local community may need to perform this kind of experiment in relation to the quality of its local environment.

or

- Suggest how the general method used in this experiment could be applied to study aspects of pollution in a public water supply.

On the whole, however, the assessment of manual skills can be generally left to the professionalism and integrity of teachers and do not necessarily need to be tested in a formal examination. The main stated justification for persisting with practical examinations in biology is that if they were to be abolished there would be consequent neglect of practical work. On the whole evidence for this claim is tenuous. On the contrary in school systems such as those of Australia which have never formally examined practical skills in biology or in school systems in which they have been abolished, there has not been any evidence of neglect of practical work. Quite the reverse. The tendency has been to increase the amount and variety of practical work and to introduce highly innovative activities including long term socially oriented project work and an excellent range of field activities, including social surveys.

13.5 The Problem of Over-Standardization

As alrealdy mentioned, the existence of centrally organized public examinations tends to stifle individuality and initiative and to lead to a uniform approach throughout a given school system. In some respects this is desirable in that it ensures that everyone covers common ground and that more senior grades can assume a uniform range of achievement in prerequisite topics. The disadvantages, however, are that opportunities for innovation and for the exploration of alternatives are minimized.

This negative aspect is especially noticeable in the preparation of textbooks. In systems with a common curriculum leading to a common terminal examination only those textbooks which adhere strictly to the topics and philosophy of the "official" syllabus are likely to be viable. Publishers therefore reject innovative manuscripts and the range of resource material is narrowed and reduced to the level of the lowest common denominator.

Similarly the range of reference books and other resource materials in a school is frequently totally determined by relevance to the formal programme and library holdings from school to school are almost identical. Laboratories and equipment tend to be much the same everywhere and one school comes to be like another. While this is convenient for administrators it is inhibiting for the healthy growth of educational diversity. When teachers come together for inservice experiences their questions are limited to "how do you deal with that part of the programme?" and they all find they are covering the common topics in much the same way. In a less convergent situation teachers develop and share a much broader repertoire of competencies.

The serious danger of this type of convergent standardization is that it inhibits growth and change. Without variability there can not be evolution. Teachers become locked in to fixed programmes and eventually come to resent and resist any change away from a comfortable routine.

In the case of socially oriented biology, overstandardization is an especially worrying aspect of the impact of public examinations. The most appropriate case studies are those which involve local issues of real meaning in the day-to-day lives of the students and their community. If the social issues and problems are centrally prescribed then the emphasis on local needs cannot be readily addressed.

In systems where examinations cannot be avoided for reasons such as those outlined in Section 13.1, something can be done to reduce the effect of this negative standardization. One approach is to regularly revise and update the examination syllabus and the nature of the examination itself. Another is to have a range of alternative syllabuses and examinations or of units within a common examination. Some school systems have biology examinations which are based on a compulsory core of material plus a wide range of elective topics. This goes some way to moderate their convergent impact. A compromise in regard to the need to focus on locally relevant case studies is to set questions which allow candidates to choose any case study which they wish to review. This approach, however, limits the range and scope of the types of questions which can be asked, and the types of analyses required.

13.6 Selection of Examiners

In the past, and it is still so in some school systems, biology examination committees have been dominated by university biology professors, particularly for the examinations held at the end of secondary education. This tradition comes from the time when the main purpose of senior secondary education was to prepare for the university. In more recent years, however, the trend has been for examinations at this level to have a wider role both in terms of catering for a broader spectrum of vocational alternatives and in terms of the goals of general education. Unfortunately very few university biology professors are trained in pedagogy. They certainly bring to examination committees an expert knowledge of subject matter, of latest research findings in biology and of trends in the discipline. But while this is important it is not sufficient. If examinations are to function effectively in stimulating an appropriate socially oriented educational response they should be constructed and administered by teams of examiners consisting of classroom teachers, curriculum experts, experts on the role of science in society, and test constructors as well as university biology professors.

In some systems the proportion of university representation on examination committees increases with the grade level of the examination: none or almost none at primary level; a small minority for the junior secondary grades and perhaps 30-40% of the committee members for university entrance examinations. Before the abolition of lower level examinations in Australia that was the general pattern - and it was generally effective. The problem of an imbalance in favour of university representation is that professors tend to defend what they perceive to be the "integrity of the discipline" at the expense of pedagogical principles.

In some systems, and once again Australia is an example, examination committees draw most of the questions for a particular examination from an item bank of pre-validated questions. These questions are collected over several years from the products of teachers' workshops. In some cases teachers are paid for each item which meets defined technical criteria and which is appropriate for the examination concerned. This technique ensures a strong input from practising classroom teachers and is a healthy counter to a purely academic emphasis. This method does not preclude members of the examination committee itself from also contributing to the item bank.

In cases where teachers attend workshops to set examination questions it is usually necessary to provide a short training course on the techniques of item writing. The examination committee should itself be cognizant of the need to continually improve its own expertize in the techniques of test construction. By having test construction experts and curriculum specialists as members of the committee the necessary technical knowledge is built in and so training for the committee as a whole can be a continual on-job responsibility.

Biology examinations which include questions such as "write an account of the life cycle of the frog" or "draw and label the labium of the cockroach" are no longer tenable. In order to ensure that examinations stress issues of social significance and meet necessary pedagogical standards they should be set by co-operative teams. The members of such teams must be seen to have equal status and to be contributing different types of expertize. Committees dominated by university professors of bioloby either numerically or in terms of authority may tend to produce examinations which emphasise academic concepts inappropriate for contemporary educational needs.

13.7 Types of Questions

Modern effective examinations are technically complex. The best include a range of item forms such as multiple choice, short-answer formats and short essays (see Chapters 10-12). These and other forms of test items have technical characteristics which need to be thoroughly understood by examiners.

In addition test construction techniques such as the preparation of an objectives/content grid need to be understood, or if mastery items are being set, the importance of the one-to-one relationship between an objective and a test question needs to be appreciated. In the case of socially oriented biology both the objectives and content of an examination should emphasise the application of biology in the analysis of social issues and the solution of social problems. Where it is possible to do so without compromising security, examination papers (or parallel forms of the paper) should be pre-tested for reliability and item validity using the standard techniques of item analysis.

As a minimum, the final draft of any public examination paper should be "answered" by small groups of representative classroom teachers. Such a trial run can frequently correct errors in timing, balance, coverage, and difficulty as well as technical, printing or conceptual faults in specific items.

In any biology examination the stimulus material on which test questions are based should be highly visual. Drawings of organisms, of experimental situations, aspects of field work and so on should be used throughout. Where possible photographs should also be used to increase the realism of situations to be interpreted in the responses required. Such devices give important signals to teachers since they encourage practical activity and first-hand contact with living organisms and with other aspects of the real world. In socially oriented biology the range of stimulus material should include drawings, photographs, statistical data, extracts from newspapers, cartoons, poems, quotations, tabulated summaries, information grids, checklists and other devices which present information about the applications of biology in society.

13.8 Influence on the Community

Public examinations are naturally enough very significant to the community. This is especially so in societies in which selection into the next level of the educational system makes a significant difference to living standards, and indeed to the overall quality of life for the individual student and his or her family.

Because of the importance given to examinations in some school systems a great deal of societal and parental pressure is placed on candidates to succeed. If taken to excess this pressure can be highly counter-productive perhaps even leading to psychological damage. In countries such as Japan where the social pressure to succeed in public examinations is particularly intense (4) the effects are felt at all levels of the educational system even down to preschool. Parents try to get their children into the "best" schools - that is the schools with good examination records. The real purpose of education is forgotten as success in examinations takes over as the overriding consideration.

This situation is particularly tragic in school systems with outmoded and socially irrelevant curricula. Frequently, impoverished parents in some developing countries struggle to keep children at school to pass irrelevant public examinations. Those succeeding in passing such academic examinations are frequently unemployable but refuse to return to the traditional life style of their parents, so causing major societal tensions. This trend is almost entirely due to false expectations about the meaning of schooling and of the significance of an examination certificate.

These social pressures frequently encourage undesirable practices such as the development of coaching colleges and "crash" preparation for examinations. The publication of examination cribs and of other short-cuts to passing the public examination becomes widespread. In some countries a whole industry develops around passing the public examinations and this is pedagogically and economically unsound. In the case of biology this is particularly worrying since the community comes to see the subject as just another element of the examination system and denigrates its especially powerful general societal role.

This latter aspect highlights the special responsibility of an examination committee in regard to community attitudes. As far as possible the biology examination should reflect current societal issues such as the conservation of wilderness areas, current health problems, recent case studies of the application of biotechnology, family planning issues and so on. Examinations should help influence public opinion about the relevance of biology to everyday life.

Examiners should also be aware of and be responsive to the use made by the community of examination grades apart from their immediate selective role. For example, if employers see that modern biology is relevant to the real world they will tend to give examination results in biology a higher status among the factors being considered in hiring staff.

Examiners should also be aware that they are fully accountable to the community. Technical errors and mismanagement in a public examination come under intense public scrutiny. But more importantly examiners should recognize that if their papers are irrelevant to the needs of a community then that community has the right to demand appropriate modification. Public participation in decisions about the role of schooling and especially of the role and nature of examinations increases with increased levels of community education and is now very evident in many countries. Examiners therefore should be responsive to community trends, while at the same time using the examination system itself to further inform people about the importance of general education, and of the special role of biology in contributing to an improved quality of life. If examiners are perceived by examination committees to have highly specific roles and to reflect only a narrow range of educational objectives then it is likely that the community will seek alternatives (Section 13.9).

13.9 Awards and Grades

There is some tendency for public examinations, particularly at lower levels of the educational system, to be replaced by alternative procedures, especially in regard to grading. Some of these are considered below.

Continuous assessment by individual schools is an obvious aternative (Chapter 9). This allows the assessment of a much broader range of educational objectives and also caters for changing interests and differential rates of maturity. One of the major weaknesses of public examinations is that they are "cross-sectional" recording the achievements of an individual at a particular moment in time. Continuous assessment enables the recording of longitudinal data, including grades, and can show improvement over time across many categories of achievement.

Considerable attention also needs to be given to alternative methods of grading, both within a formal public examination system and within programmes of continuous assessment. For example Pass/Fail grades could be considered for topics involving mastery learning. In some instances, no grading at all may be needed, merely an indication that a student has attended a particular programme or unit of work.

"Profiles" are becoming increasingly popular for recording achievement. Instead of a percentage, alphabetical or Pass/Fail grade for a subject as a whole, an indication can be given of achievement across a range of individual elements or components of the subject. In a mastery learning situation all the skills and concepts which have been mastered could be listed. Or alternatively components of the subject such as experimental design; dissection skills; knowledge of principles; use of apparatus; skill in analysing social issues; field techniques; problem solving skills and so on could be listed and given individual grades.

The trend away from the award of a single overall grade for a subject such as biology has emerged partly in response to community demand. Potential employers and others have difficulty in interpreting letter or percentage grades for a whole subject or of understanding percentiles or other indicators of ranked position. They are more interested in evidence of competency and so the more detailed data provided in a comprehensive dossier (perhaps in the form of a profile) are much more meaningful. Such reports also provide for information on attitudes and interest and on manual skills which would not be separately identifiable in an overall grade.

More complex forms of assessment and grading do present some problems for those seeking a single index for selection into a university or a higher grade of education. It is possible however to quantify these types of data and to derive an overall index. If necessary, such an index could be moderated by requiring candidates seeking entry into a particular programme to take a specialized test or a test of general ability. This is a fairly common practice for example in some specialized areas such as medicine or business management.

13.10 Conclusion

The importance and significance of public examinations diminishes as a community evolves towards becoming a learning society (5). As the principle of lifelong learning becomes more clearly established, public examinations, if they occur at all, are seen to be relatively small steps in a continuing process of personal growth and development.

This trend is inhibited if public examinations function as barriers instead of gateways. In learning societies, however, the emergence of an effective non-formal system of education for adults can go a long way to compensate for previous deficiencies in formal education - including previous failure to attempt or to pass a particular public examination. The fostering of non-formal programmes in biological education is therefore important if the subject is to play a central role in the lifelong learning of the majority of citizens.

Systems of informal education through the mass media, at community centres, in libraries and so on, can also compensate for the negative effects of an examination barrier. Self education can occur only in an environment which encourages individuality and especially acceptance by an individual of responsibility for his or her own learning. For such people a public examination can change from being a barrier to becoming a gateway.

The central message is that flexibility in any system of education and in particular in the use of public examinations is very important. All citizens should have open access to any system of public examinations at any stage of their lives. While examinations in biology are only one small part of this general pattern it is important for biology teachers at all levels to realize that their role transcends their immediate classroom and contributes to the educational wellbeing of the community as a whole. This is especially so if examinations focus on issues of social relevance.

Notes and References

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Tanaka, Ryuso (Ed) Biology Education and Environmental Education in Japan as an International Society. Hiroshima: Ryuso Tanaka 1985 150 pp.

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PART IV

FACILITIES AND RESOURCES

Introduction to Part IV

Any programme of secondary school biology requires a range of educational facilities such as classrooms, laboratories, science equipment, libraries and school gardens; and learning resources such as textbooks, teachers' guides, individual resources, computer systems and so on. In addition resources outside the school such as zoos, museums, public gardens and ecological field sites are required. In a programme of socially oriented biology this range of facilities and resources is needed but in addition such a course should make greater use of the wider social environment.

Various biologically based primary and secondary industries can be exploited as can health services, the mass media, industrial leaders in the local community, local government resources, housing, family groups and the general work environment. In developing countries a particularly important resource is to be found in analysing traditional practice in areas such as crop farming, animal husbandry, fishing, communications, health, craft and housing.

This part of the book briefly reviews aspects of the resources and facilities needed to implement a course of socially oriented biology. The coverage excludes an account of the details of biology classroom and laboratory design, lists of scientific equipment, the general qualities of good textbooks, how to conduct field excursions and so on as these aspects have been exhaustively treated in a range of recent publications by Unesco. These publications include various volumes on the production of low cost scientific and audiovisual equipment and resources; the "new trends" volumes; the series of publications in the Science and Technology Education Document Series, the various Unesco "source" books on the teaching of science and the series of regional handbooks for the teaching of biology such as the Unesco Handbook for Biology Teachers in Africa and the Unesco Handbook for Biology Teachers in Asia. These and other relevant publications are described in the general reading list at the end of the volume.

The approach here is to provide brief guidelines and suggestions for managing and utilizing facilities and resources to promote the achievement of socially relevant objectives. Chapter 14 deals with the more usual facilities of the school such as classrooms, laboratories, science equipment and the school grounds and comments briefly on how these more traditional resources could be developed and managed to focus more on societal issues rather than on scientific aspects alone.

Chapter 15 reviews facilities and resources outside the school such as ecological field sites; sites illustrating socially sensitive environmental issues; the home; farms; community welfare centres; community learning centres and libraries; vocational centres; housing estates; traditional practice in various areas such as health and housing; industrial and commercial institutions; the mass media and so on. Since the aim is to understand the relationship between biology and society and to review the application of biology in social issues and in resolving social problems, then it is the effective use of these broader community resources which require special attention.

A review of exemplar content and activities provided in Part II quickly reveals that the emphasis in socially oriented biology is the community. It is important, therefore, that teachers appreciate the great potential of the community as a resource for teaching. They should become familiar with various local agencies, institutions and facilities and also should establish effective links with individuals and groups who can support the programme. Community involvement is the key to success in this type of programme.

Chapter 14

SCHOOL FACILITIES AND RESOURCES

14.1 Introduction

If a comprehensive list is to be prepared of facilities and resources needed for an ideal programme of biological education several categories immediately come to mind. These include well-designed and well-equipped laboratories; specialized appropriately furnished and stocked classrooms; storage and maintenance facilities; facilities for keeping living organisms; appropriately designed grounds; good textbooks; teachers' guides and activity books; high level library facilities; an appropriate range of scientific apparatus and consumable materials; appropriate audio-visual equipment; computers; and an effective range of clerical resources. In other words good quality biology education can be expensive.

In programmes of socially oriented biology this full range of requirements is still required but with a certain change in emphasis in the design of rooms and in the exact nature of equipment and learning resources. One point needs to be strongly emphasised. Shifting the emphasis from a purely scientific approach towards a more socially applied approach is not an exercise in cost-saving and in fact could entail more costs than for the more conventional approach (1).

14.2 The Biology Room

Ideally all the biology teaching should occur in an especially equipped biology room which has the combined function of a laboratory and a more conventional classroom. Few schools, however, can afford such an expensive facility for all students since there are too many classes competing for the space and timetabling becomes complex. Most schools therefore have one or more laboratory type rooms for science-based practical activities and, hopefully, modified classrooms for other types of learning activities.

Another general point needs to be emphasised about the type of rooms used for teaching socially oriented biology. The teaching methods not only include the science type methodologies of the conventional approach but also many of the methodologies once thought to be the sole province of the social sciences - especially interpersonal games, simulations of community situations; case study analysis and so on (2). The teaching spaces both in the laboratory and the classroom must cater for this added dimension.

(a) The Laboratory

A well equipped and designed laboratory type room is essential for the effective teaching of biology, whether a conventional or a socially oriented approach is advocated (3).

The effective laboratory requires running water, gas (either mains or cylinder), electricity, good lighting and appropriate fittings and furnishings. A design with services along side benches and with movable benches and stools in the central teaching area is probably the most effective for more junior grades. Senior grades may need fitted and serviced benches for small groups of up to four students.

In socially oriented programmes a small group approach is important involving discussion, interpersonal simulation games, role playing and so on as well as the more conventional scientific activities and so an area of the laboratory type room should be set aside for this purpose. It should have flexible furnishings such as small trapezoid tables and comfortable stacking chairs which can be re-arranged quickly to accommodate the needs of groups of various sizes from pairs to groups of five or six students.

As in conventional school laboratories a demonstration bench at the front of the room is essential, equipped and serviced with all facilities. There should be plenty of cupboard space for student kits of basic apparatus and for other resources. Pin boards, and other display facilities are also important. These should be used to display results of community projects and also be available as current affairs bulletin boards. Each laboratory should be linked to a preparation room which may also serve as a storeroom for chemicals, and for certain items of less frequently used equipment. This room could service perhaps two laboratories, one on either side.

This basic pattern is typical of thousands of school biology laboratories throughout the world. In schools which have only one laboratory to be shared by many classes or which have inadequately designed or equipped laboratories certain compromises have to be made. The essential point however is that effective biology teaching is impossible in the absence of practical work. What is required is that each school be given sufficient autonomy in its curriculum design to be able to undertake the type of practical work most appropriate for its laboratory resources and facilities. Some activities can be undertaken in ordinary classrooms or in the school grounds, but every effort should be made to offer sophisticated experimental work, if necessary by utilizing improvised or adapted resources. Spirit heaters, teacher-made apparatus, temporary plumbing facilities, teacher made charts, "home-made" weighing balances, and so on can be highly effective. If, however, a school course is so centrally prescribed that each piece of practical work to be undertaken is identified, it can inhibit initiative. A teacher may well ask "we do not have the facilities for that, so why bother with practical work at all?" Syllabuses of practical work therefore should be advisory not prescriptive. This is one reason why practical tests as components of public examinations are frequently counter-productive, especially in school systems where facilities are minimal (see Chapter 12).

A prescribed "set" of practical activities within a programme of socially oriented biology is especially counter-productive since the science type observations, experiments or other activities to be undertaken have a service role as tools to investigate scientific aspects of locally identified social issues and problems. Flexibility is essential as the class investigates those changing situations and issues which are of concern to the local community.

(b) The Classroom

Classrooms are less expensive to equip than laboratories but it is especially important that wherever possible a specialized biology room be established for lessons other than those given in the laboratory or out-of-doors.

The "fixed-furniture" type room is inappropriate for effective socially oriented biology teaching. It implies that only the lecture mode of presentation will be used. As in the case of the laboratory, light weight moveable tables and chairs should be utilized so students can form groups of various sizes for different activities such as discussion groups, simulation games, planning activities and so on. The "demonstration" bench is also less important in such a room but some specific areas for the teacher to set up displays or demonstrations are desirable.

The biology room could perhaps have facilities such as aquaria, vivaria, nests, growth boxes and so on for keeping and displaying living organisms that are relevant to any particular issue under consideration. These could supplement similar facilities set up in the laboratory.

Incidentally, both the laboratory and the classroom should be the optimal size for the number of students since "activity" oriented lessons characteristic of modern socially relevant biology teaching do require space. Both the laboratory and the classroom should have facilities for darkening the rooms so that audio-visuals can be used.

One of the important reasons for establishing a special biology room is that long term demonstrations and displays can be set up without interruption or interference by other classes. This is important in biology where certain studies may require several days or even weeks.

A poster display and a current affairs board are important features of a biology room. If the subject is to stress issues of social relevance the current affairs board should be kept up-to-date by displaying articles of relevance from newspapers, magazines and so on.

One thing that should be avoided in both laboratories and specialized classrooms is the temptation to use them as store-rooms for unused textbooks or rarely used items of equipment. Everything in these rooms should be relevant to the learning experiences of the moment.

In the absence of adequate laboratory facilities the specialized biology classroom takes on an even greater significance. Many types of practical activity can be undertaken in such a room. Studies of structure, certain types of experiments, observations of behaviour, the analysis of data and so on, the review of socially relevant documentation, are all possible in a modified classroom as well as in the laboratory. The important rule is that facilities available should be utilized to the full.

14.3 Scientific Equipment

One of the most important points about equipment is that the syllabus (curriculum) determines what is needed, it is not the equipment which determines the syllabus. That is not to say that a piece of equipment if available cannot sometimes stimulate a teacher to organize an interesting lesson. What it does mean is that a purchasing policy should not be determined solely by the desire to have the latest most sophisticated piece of equipment just to explore its potential or to appear to keep up-to-date. Purchasing should be in terms of the needs of the programme. As in the case of laboratory and classroom flexibility of use is an important criterion for science equipment. It must be suitable for the types of science activities needed to investigate the scientific aspects of the local social issues chosen for investigation.

Another aspect of equipment is that the number of more expensive items such as microscopes may have to be built up over several years. Fortunately most modern microscopes designed for use in schools are sturdy and easy to maintain. If adequately looked after they will last for many years and so the numbers can be gradually increased from year to year.

A third point about equipment is that it has to be adequately stored and competently maintained. Special storerooms for less frequently used items are needed. Items used from day-to-day should be stored as close as possible to their point of use - preferably in the laboratory or the biology room. They should be made easily accessible for staff and students.

Equipment not maintained in good working order represents a waste of capital investment and a reduced opportunity for innovative teaching. Biology teachers should be able to perform simple maintenance tasks themselves or else have access to a system which can respond quickly and inexpensively to maintenance needs. This is especially important in remote areas where "service" facilities are minimal. In such cases only items which can be easily maintained should be purchased in the first place. Items of equipment, at least for schools, which have to be sent to a major city or to some other country for repair should not be purchased.

Improvisation of low cost alternatives is highly recommended. At school level the precisions of the university research laboratory are not required. Equipment at school level is used to develop an understanding of concepts, principles and generalizations; to develop some manipulative skill and to help pupils understand processes and procedures. As long as these objectives can be achieved by using simple less "precise" items of scientific equipment, then this is usually sufficient. This implies that it is frequently unnecessary to achieve precision in measurement or to obtain highly accurate quantitative results. Therefore simple teacher-made measuring devices or items such as ordinary kitchen scales or pieces of apparatus put together from low cost locally available materials may be adequate. And certainly in the absence of alternatives, such resources are essential. Once again the excellent publications by Unesco on this aspect are highly recommended (4). In addition guidebooks produced by the Science Teaching Center of the University of Maryland USA are most useful (5).

The improvisations, management and maintenance of equipment involves a specific range of competencies. Teachers of biology need to acquire these competencies and this highlights the need for inservice programmes especially directed towards this end

Finally for a list of recommended basic science equipment for a biology laboratory readers are referred to Unesco's Handbook for Biology Teachers in Africa, especially pages 211-245 (6).

14.4 Clerical and Communication Resources

It is patently obvious that the quality of any educational enterprise is dependent on adequate clerical resources both in terms of personnel and of material facilities. Teachers who must spend a high proportion of time on typing, duplicating notes, filing, compiling administrative data, filling out forms and so on cannot give their full attention to their central task, which is education.

Educational systems which fail to provide adequate clerical support for teachers are not cost effective. It does not make a great deal of sense for a qualified teacher on a high salary to be required to perform tasks which could be undertaken by others on much lower salaries.

Another aspect of the need for effective clerical support is the importance of developing and maintaining coordinated systematic clerical services which as much as possible reflect the state of the art. In other words, if electronic typewriters replace manuals or word processors replace electronic typewriters, all necessary consequential changes in staffing and resources should be implemented at the same time.

It has been stressed that the effective biology teacher is responsive to change and is innovative, taking opportunities as they arise. Clerical facilities therefore should be equally responsive. Unfortunately all too frequently something as simple as the absence of a part-time typist or the breakdown of a photocopier causes a major hold-up and affects what happens in the classroom. Since clerical support needs to be available at all times it should be carefully budgeted and back-up systems provided wherever possible.

These points are especially significant in the case of socially oriented biology since the amount of clerical work is generally greater than is the more conventional approach. Social survey reports need to be prepared; materials for simulations such as "in-basket" methods must be developed; resources are needed for case studies and so on. A broad range of printed resources are needed for the input, process and output stages of almost all learning activities and fail safe clerical support is essential.

On the communication side effective links with the general community are essential if socially oriented activities are to predominate. There should be an effective telephone system and if the school can afford it, there should be a FAX machine available. At the very least the school should maintain a public notice board at a prominent location in the community. This should be used to solicit help for projects; to inform the community of current activities and to generally promote effective liaison between the school and the community.

14.5 The School Grounds and Other Facilities for Keeping Live Organisms

Effective biology teaching requires access to living things not only in their natural environment, but also directly in the teaching institution itself. This implies that in universities there should be glasshouses, bush houses, warm rooms, aquaria, vivaria and so on as well as animal houses for the breeding of insects, rats, mice and other laboratory animals. Microbiological laboratories are also required for the breeding of fungi, bacteria and other microorganisms.

At school level the range of resources for keeping and breeding living organisms of necessity must be more restricted. Nevertheless every biology room or laboratory can have freshwater aquaria and simple vivaria. Some innovative schools have resources such as special vivaria for lizards, observation ant colonies, demonstration bee hives, breeding cages for white mice and so on. Most can also provide growth tables for potted plants and some can establish simple low cost bush houses (7).

Keeping and breeding plants and animals at school naturally enough brings its problems and responsibilities but these can be overcome. Boarding schools - especially in rural areas - usually have the least problems because there are people available to look after the organisms during vacations and weekends. In day schools after-hour rosters have to be established or else the organisms may have to be taken to the homes of students during the longer vacation breaks.

An important aspect of keeping living organisms in the laboratory or biology room is that they not only provide resources for routine observation of structure and growth, studies of behaviour and so on, but they foster a sense of responsibility and commitment on the part of students who come to see the importance of guarding and protecting forms of life other than their own. It is therefore important for students to accept responsibility for looking after them. Further the presence of living plants and animals in the school provides opportunities for innovative project work which otherwise would not be possible.

On the whole while keeping and breeding living things is fairly labour intensive, it is economical in terms of equipment and other resources. As the work involved should be undertaken mainly by students, financial aspects are usually relatively insignificant. A good well-organized collection of living things can sometimes compensate for other deficiencies caused by lack of funds.

The grounds of the school are also an important resource. Schools with only asphalt or concrete grounds miss many opportunities for biology lessons. Something can be done however even in such situations.

For example, the distribution of weeds in cracks and corners or of moss and lichen on posts and walls can be studied or the behaviour of ants and flying insects or of birds visiting the grounds can be observed. Nevertheless every opportunity should be taken to maximize the potential of the school grounds for the teaching of biology and this can be achieved usually with very little expenditure.

A corner of the grounds set aside for trees and shrubs and left relatively undisturbed is especially useful. Studies of growth, seasonal changes, plant and animal associations, adaptations, leaf litter ecology, soils and so on are all possible given such a simple resource. Garden ponds, patches of lawn, garden beds and fern houses are all easily established and extend the range of possibilities.

In some large institutions special nature gardens can be established for a representative range of local plants. Boarding schools in rural areas, especially in developing countries, frequently establish kitchen gardens or even small farms to serve domestic needs. With appropriate cooperative planning these can also be used for biology lessons - for example studies of the effects of irrigation or of the use of fertilizers (8).

One especially effective technique in schools which have developed their grounds with biology lessons in mind is the establishment of "nature trails" with "stations" at points of particular interest such as the pond, fern houses, grassy plots or grove of trees and so on. A variety of lessons for different grades can then be planned using the nature trail as a conceptual focus.

As in the case of keeping and breeding animals and plants in the biology room or the laboratory, well planned and fully utilized school grounds can help compensate for other deficiencies in situations of budgetary constraint. Whether or not that be the case, however, the grounds of any teaching institution should be carefully planned and managed to extend the range of teaching opportunities for the biology staff.

In programmes of socially oriented biology the use of living organisms and the effective use of the school grounds provides a resource for many experiments relevant to the needs and interests of the local community. Just a few examples which come to mind include helping students develop home gardens for possible cultivation and sale of economic produce; trying out various aspects of farming practice; studying the use and effects of garden fertilizers; studying alternative soil conservation procedures; investigating the impact of pollution on the physiology of plants and of invertebrate animals and so on.

14.6 School Library

Just as the extent of clerical support can determine the quality of any educational enterprise, so too can the effectiveness and characteristics of its library resources. This is of course a major topic and only a few aspects of direct application to the teaching of socially relevant biology are considered here.

The first point to emphasise is that at school level a library collection should closely correlate with the needs of the curriculum. There is a temptation to buy the latest titles from publishers' lists just because they represent new approaches or are by eminent writers. That policy is essential for a university, but is not so relevant at school level. The essential thing is to buy up-to-date items which also closely match the content of the course. At school level it is important to distinguish between "must have" and "it would be nice to have".

As has been stressed throughout this volume there have been very significant changes in curriculum emphasis in biology over the past two or three decades. School libraries should reflect these changes by keeping up-to-date in areas such as biotechnology, the environment, population studies, health and in other areas of social relevance. That is not to say that older types of books emphasising structure, life cycles and taxonomy should be discarded. After all these concepts are still valid. Such books may perhaps be placed in a reserve collection. What may need to be deleted are older style textbooks (not reference books) which give false views of science as a body of dogmatic fact. Even these books, however, may have value if used to highlight differences between older and more recent interpretations of science.

Purchasing policy for the library should therefore be determined by cooperative interaction between teachers and librarians. The biology staff should advise on curriculum trends and suggest additions and deletions.

A more general issue in library organization is the extent to which technical aspects such as cataloguing and classification can be facilitated by a central agency, such as the library services of a university or State Authority. Computer generated catalogue cards distributed to individual schools, especially if linked to a central purchasing system, can effect considerable economies. In universities computer links to data-bases are also highly cost effective. In biology these data banks are now very extensive and provide highly efficient services including the preparation of specialized bibliographies. In the United States the ERIC system also provides a major source of computer-linked data on pedagogical issues.

There is a general trend to convert book collections into multi-media resource centres which also have production roles. This trend is important for biology since audio-visual technology has such a significant role to play in that subject. One aspect of resource centre management is the trend towards establishing decentralized learning stations at relevant points in the school such as the biology room or laboratory. These are usually managed cooperatively by librarians and biology teachers and provide multi-media resources for individual study or for group activities. This trend is totally consistent with the principle of learning that suggests that learning is most effective if the elements studied are brought together as closely as possible in time and space. Further, by associating library resources with those in the biology areas, appropriate conceptual links can be readily established.

One aspect of library services that is frequently overlooked in educational institutions is the need to cater for the separate specialized pedagogical needs of staff. While some school libraries do cater for this to some extent, this aspect could be greatly improved. Building library resources for teachers about pedagogy is a highly cost effective approach to inservice education and staff development.

Library education is another aspect that is frequently overlooked by subject teachers - particularly in the sciences. Biology teachers should work closely with library staff in training students in the effective use of the library. In more senior school grades it is important for students to understand how to use more specialized sources of information such as research journals, cumulative indices, data banks, citation indices and so on. Structured activities for students designed cooperatively by library and biology staff are essential in developing this understanding.

In socially oriented biology the "character" and profile of the library collection should reflect the socially relevant objectives and content of the programme. This means that the collection should include a broad range of local, national and international journals, magazines and newspapers; reports from planning authorities; policy statements by government and other development agencies and so on. There should be a big collection of relevant photographs, tape recorded interviews and other locally generated materials. Teacher and student made resources should be an important part of the collection. Reports prepared by students of social surveys, reports of case studies of locally significant problems and other similar materials should be collected and made readily available to students and staff.

Finally, on the matter of library services, especially those catering for socially relevant education, great care should be taken to resist community pressures to censor the collection. Unfortunately certain minority groups in modern society hold unorthodox or extreme views about certain issues such as sex education, birth control, race, evolution, conservation, the origin of life and so on. They may attempt to have certain books deleted from the library collection. The point is of course that any book in the legal public domain is also potentially in the educational domain. The only criterion for selection should be in terms of the needs of the curriculum. Pressure for censorship from unrepresentative groups should be ignored.

14.7 Textbooks

Socially relevant biology focuses on problem solving and the development of critical thinking in the application of biology to the analysis of social issues and the resolution of social problems. The older style textbook was frequently just a source of printed factual biological information, poorly illustrated, and containing little to stimulate learners by means of questions, suggested projects, alternative readings, references, laboratory activities and so on. Socially relevant examples were rarely if ever included. All too frequently schools kept outmoded, even out-of-date books which were educationally counter-productive (9).

Another weakness of poorer types of biology textbooks was that they failed to reflect the true dimensions of science. There was little about the processes of science or about how scientific knowledge changes. The worst of these books were little more than examination cribs emphasising a false status quo in science and encouraging dogmatism and straight out memory work.

There is a growing tendency to make the textbook more than just a statement of content. Most modern tests are also Study Guides. They hep students learn the content. They provide vocabulary lists, summaries, suggestions for further reading, suggestions for activities, ideas for discussion, and opportunities for "self-check" evaluation of progress in achievement through questions and tests. Some also include instructions for practical work so that the learning activities are smoothly sequenced and integrated. In others, practical work is developed separately in a parallel book which is usually produced as a work-book in which answers are to be written. This latter technique is not the best method since it can cause interference in learning, due to discontinuity.

The combined text/study guide/practical manual should be simply written, logically organised and well and clearly illustrated. Each topic or unit should begin with clearly stated objectives and perhaps each sub-unit could have stated behavioural outcomes. The suggested activities should be as open and unstructured as possible to provide opportunity for creative discovery. Instructions for practical work should be clear, logical and unambiguous. Full details of technique should be given when it is required for the solution of a problem, eg. steps in analysing a social issue should be set out in logical order and illustrated by drawings and photographs. Resources required for each activity should be listed.

Questions could be of two types: firstly, those which require logical recall of information and facts organised to provide an over-all summary; secondly, those which test the achievement of specified objectives and general objectives such as those of Bloom's taxonomy (comprehension, application, analysis, synthesis and evaluation). Because questions in a textbook are mainly included for self evaluation, answers should be provided or an indication given as to where the answers can be found. Questions for discussion should be provocative and stimulating. The reading lists should be annotated and include only readily accessible publications at an appropriate level. A comprehensive classified index could be provided and the book should have a well organised table of contents.

Layout of a textbook is important. The size of the page and the type ust be carefully selected for maximum readability and there should be a high proportion of 'white space' on each page. The amount of information on each page should be kept as low as possible - perhaps to one or two central ideas only.

Finally, modern textbooks in biology stress modern views of science. Readers should be given an insight into how science works; to the achievements of individual scientists; to the role and characteristics of the scientific community; to the limitations of science and above all to scientifically based issues of social relevance. Issues such as bioethics and of the determination of an appropriate scientific policy for a community or a nation should be highlighted.

Books which fail to meet these criteria should be used with caution. In schools which cannot afford to replace old stock supplementary materials may need to be made available. Activity sheets could be mimeographed; case studies printed and so on. Close adherence by teachers and pupils to unsatisfactory textbooks should be avoided at all cost.

14.8 Teachers' Guides

The best textbooks are accompanied by teachers' guides. These are especially useful to stimulate the exploration of teaching alternatives and have a particularly valuable role in orienting a teacher to a new programme or a new teaching situation. For a course with a new orientation such as teaching for social relevance they provide a key inservice role.

The most flexible guides are published in volumes or units corresponding to the broad divisions of the school grades. This keeps together relevant graded materials, retains flexibility and makes the one guide available to several teachers at the one time.

The first volume should contain an over-all statement of the philosophy of the course. It should state and discuss the objectives; give a summary of the main content with the rationale for choosing each topic and discuss and explain the recommended teaching strategies. For the approach advocated in this volume issues raised in Chapters 1 and 6 to 8 should be set out in point form. Each volume should also include a section on special problems and interpretations for the particular grades concerned.

The main part of the guide should give specific advice on the teachings of each topic or unit specified for the grade. The following headings may be useful:

(a) Assumed knowledge: A statement of the pre-requisite knowledge, understandings and skills that pupils would need to understand the topic. Advice on assessing this standard and on remedial action necessary to bring the pupils to the required level.

(b) Purpose of unit: A statement of the general and specific objectives and behavioural outcomes recommended for the unit. Some discussion of points of special emphasis in the teaching and a brief summary of the rationale for the manner of presentation adopted in the text.

(c) Comments on text: These could be interpretations or elaborations of concepts in the text. In this section, too, precise instructions for and advice on organising and setting up experiments, social surveys and community case studies, and other specified practical work could be included. This section should be liberally illustrated with photographs and line drawings.

(d) Additional activities: Teachers should be advised on additional practical work and other socially oriented activities. These are important to provide enrichment to allow alternatives in the curriculum and to cater for individual differences. Full instructions should be included and the section should be illustrated by diagrams and photographs.

(e) Teaching resources: Sources of learning materials and advice on this use could be listed under the following headings (10):

- special laboratory kits
- models
- charts
- locally produced printed materials (government reports etc.)
- prepared chalkboard/flannelboard,pegboard
- 8mm films
- 16mm films
- 35mm slides and strip films (preferably teacher made)
- books and pamphlets (especially dealing with social issues)
- magazine articles (local issues)
- programmed materials
- video taped programs of local situations
- audio taped programmes (mainly interviews)
- computer programs
- other aids.

(f) Biographical notes: A very short summary of the lives and careers of each biologist and local personality mentioned by name in each unit (illustrated by quotations from writings by the biologists concerned).

(g) Answers to questions included in the text: It is important that all questions in the text should be fully answered and discussed in the Teacher's Guide.

(h) Additional questions (with answers) not in the text: It is useful to provide teachers with a reserve of additional questions, preferably involving understanding rather than mere recall of facts. Answers to these questions should be provided. All should have a social orientation.

(i) Topics for discussion: Topics for class discussion should be recommended. These should be on broad speculative issues about humankind and the environment. They should stress issues of social relevance.

(j) Sample test questions: A range of objective and short-answer type questions should be included for building tests and examinations. Answers should also be provided.

The rest of the guide should contain certain discussions of general problems and techniques of biology teaching. Topics for discussion could include the following:

- care and use of the microscope
- care and use of balances; spectroscopes and spectrometers; vacuum pumps and barometers
- elementary glass work
- safety precautions in the laboratory
- advice on simple bench work - soldering, etc.

preparation and supply of stock solutions
biological stains and staining techniques
animal dissection; techniques and care and use of instruments
killing and preserving animals
making an herbarium collection
organising a school museum
organising displays of social issues
setting up a biology room for social relevance
using the school garden to teach biology
procedure for field excursions, social surveys and other visits away from the school
improvising low cost apparatus
producing audiovisual materials
using computers
general references and resources.

A final point about teachers' guides is to stress that they can greatly enhance the over-all quality and effectiveness of teaching. In the absence of a guide, teachers from a given region could perhaps consider meeting together in a series of workshops to write and print (mimeograph) their own guide to be used with an agreed standard textbook. Clearly such a locally produced guide may not include all the elements suggested above but even basic suggestions on how to maximize the effectiveness of the textbook for emphasising the applications of biology in society would be better than giving no guide at all.

14.9 **Audiovisual Resources**

There are several points to be emphasised about the purchasing, storage, maintenance and improvisation of audiovisual equipment and learning resources (11). The first point is that biology is an intensely visual subject and so colour slides, movies, video-taped programmes, overhead transparencies, charts, models and so on have an important role. The standard audiovisual functions of enlargement and reduction, making the abstract real and bringing remote objects into the compass of ordinary experience, apply particularly to biology. A good colour movie or video programme can bring the arctic tundra into a school room in the tropics.

The second point is that to be used to the maximum effect audiovisual programmes should not be seen merely as additions or aids to make a lesson more interesting - they are sources of information just as are textbooks or reference books and as such they can provide the central focus of any learning unit. Equipment should be purchased which facilitates the use of audiovisual materials by large groups, small groups and individuals.

A particularly important aspect is the relationships between software and hardware. Just as with scientific apparatus the purchase of audiovisual hardware should be carefully thought out. For example there is little point in buying specialized audiovisual equipment for which software is unavailable or very expensive. It is usually best to limit purchases, at least initially, to basic items such as slide and movie projectors, video systems, overhead projectors, audio tape recorders and players and so on.

Slides, movies, video-programmes, audio recordings and so on made by teachers or produced cooperatively by teachers and pupils, are frequently very valuable additions to the library. Equipment and facilities should therefore be bought with simple production techniques in mind. A range of resources for graphic art, microphones, perhaps an inexpensive video camera, certainly a low cost photographic camera and so on are probably more useful than more expensive specialized hardware. Teacher made materials are usually directly relevant to the curriculum and hence are particularly effective. Records taken of student activities such as field, work and social surveys, laboratory experiments and so on are especially useful. Tape-slide sets or video programmes of topics based on socially relevant school projects add to the learning resources.

Equipment and software for biology, just as for any other subject, should perhaps be stored and maintained by the library, functioning as a resources centre. Equipment used continuously in the laboratory or the biology room such as overhead projectors should be on permanent loan but still remain the responsibility of the staff of the library resource centre. This ensures uniformity in areas such as maintenance, purchasing, borrowing and so on and maximizes effectiveness.

A final point about audiovisual equipment is that it provides opportunities for teachers to extend their range of teaching methods. Multi-media kits, audio-tutorials and programmed materials enable self-paced systems to be introduced. Some types of audiovisuals such as listening stations are excellent for small group work. Production facilities enable students to make their own learning resources and so on.

In conclusion, it is clear that an educational institution without basic audiovisual resources is likely to be less effective than one that is well-equipped. It is vitally important, therefore, that teachers in poorly equipped schools build up cheaper forms of software such as self-made charts, posters, transparencies, colour slides and so on. If slide projectors are not available hand viewers should be used. If an overhead projector is too expensive, then a wooden light box might be improvised. In some instances equipment such as tape players may be borrowed from the parents or hired at low cost from a local company. Incidentally, the lending services of museums should not be overlooked. They frequently have slides, movies, mounted biological specimens and so on to lend to schools. In every way possible non-book learning resources should be developed to provide for the needs of the curriculum.

14.10 Educational Games and Other Simulations

Educational games and other forms of simulation are very important for teaching socially oriented biology (12). Simulations are scaled-down simplified models of some real life situation, problem or activity. In the most effective simulations, semi-dramatic methods are used, with participants assuming roles and behaving according to a set of rules or guidelines. An especially important aspect is that simulations provide no-risk situations in which various alternative scenarios can be explored without real-world commitment but in which vicarious experience of the real world is possible.

A list of various forms of simulation and their characteristics is provided below (13).

(i) Role play. The simplest form of simulation is role play in which the effects of personality, bias and vested interest and so on are explored in the processes of decision making - role play emphasizes peoples' characters and their influence on groups. It does not imply "acting" on the part of the participants but rather that the likely attitudes and values (and hence arguments) of an assigned personality be adopted during discussion. It can help explain controversial policies and issues in terms of people and their personalities. Usually limited to small groups.

(ii) Sociodrama involves a group in reading and analysing a short scripted conversation stressing human interactions and relationships. Participants are not allowed to move about but must simply read their parts, using feeling and emotion to portray their roles. Special techniques such as use of "doubles" (a simultaneous reader), "sympathisers" and "antagonists" (one of each assigned to each character in the script) and objective observers, can ensure that all members of the group are involved.

(iii) Creative drama is a more open form of simulation. Rather than just reading a script, participants play interactive person-to-person games (eg. to devise a group story with each participant adding only one word at a time). This technique can be very powerful in terms of subject matter content but more significantly it develops generally transferable skills required for good interpersonal relations; cooperative decision making; leadership; communication skills and so on.

(iv) Board Games. Board games can simulate structured problems of the real world (eg. management, quality control, etc.). They involve rules, judging, winning, losing, chance and probability, tension, competition, cooperation, tactics and strategies and organization. They provide opportunities for carefully controlled simulations totally free of genuine risk. Such games provide for the exploration of alternative scenarios by powerfully illustrating the consequences of various approaches to the solution of a problem.

(v) Simulated case studies. These recreate a "model" of reality but without the gaming elements of chance or competition. Simulated case studies can be analysed in the same way as real-world examples but without risks or threat.

(vi) In-tray or in-basket methods. This is an especially interesting form of simulation which stresses the impact of human personalities. It involves individuals or groups reading the in-tray correspondence of a particular person who must make a decision on a critical issue (say a scientist, a government minister or a local businessman). Problems are explored and resolved in a social context.

(vii) Interpersonal games. Groups follow through a structured set of activities following a set of rules, usually in teams. The aim is usually to explore the social consequences of certain actions or policies.

Simulation and dramatic methods are among the most powerful for achieving objectives of relevance to real life. Unfortunately this whole area is frequently neglected by many biology teachers who quite incorrectly believe that these approaches are more appropriate for the humanities and especially for language arts.

The vicarious aspect of simulation is especially important where real issues are sometimes politically sensitive or highly complex. Well organized simulations encourage objective, emotion-free analysis and can allow the teacher to cut away unnecessary trivia and focus on central issues.

The most effective simulations utilize dramatic or semi-dramatic methods but sometimes dramatic methods have value in their own right. They help to establish empathy between individuals and groups and to increase social skills of central importance in day-to-day living.

An important aspect of simulation and of dramatic methods is the debriefing phase. Concepts, processes, skills and values emerging from such activities must be made overt by the teacher and thoroughly discussed. All links to the main-stream subject matter of the biology programme must be established and emphasized. Unless these aspects are given strict attention, these methods lose most of their educational significance.

Many educational games and other forms of simulation are available commercially but probably the best and most effective are those improvised by teachers and students. Some suggestions for simulations are given below (14).

Role play

* Organize and effect a role play in which a committee of scientists and community representatives is to determine policy with regard to drilling for oil amongst coral reefs within a marine national park.

Sociodrama	* Organize and act out a sociodrama reading from a script on the theme "what if there is a galactic civilization?" As a preliminary phase the class may be required to write the script.
Creative drama	* Using the techniques of creative drama, play a group game such as "lemon". In this game a group forms a circle, each member must have eyes closed and is given an object, actually a lemon, and told to get to "know" this like a person. Each must give the lemon a name and introduce it, with appropriate background, to neighbours in the circle. Still keeping eyes closed, participants then place the lemons in the centre of the circle. After returning to the circle, eyes are opened and each participant is then invited to try to retrieve his or her lemon. In "debriefing", ask questions about group processes involved: the biology of fruits; use of sense organs, problems of perception and so on.
Board game	* Have the class design and play a board game to illustrate a key ecological issue such as competition for resources; overpopulation; the energy crisis or conservation versus development.
Simulated case study	* Prepare folders containing simulated newspaper stories, official reports and accounts of interviews with health authorities, patients and community leaders about an outbreak of a parasitic disease in a specified region. Working in groups the class should analyze the case study and recommend a course of action to eradicate the disease.
In-tray (In-basket)	* Organize and present an "in-basket" simulation based on a hospital case study where a surgeon must decide whether or not to attempt a kidney transplant operation on a patient with only 40% chance of surviving the surgery. Correspondence examined could include medical opinion; administrative memos; letters to and from the patient; letters from the patient's family and a letter from the patient's lawyer.
Interpersonal game	* Organize the class into simulated groups arguing for and against the idea of evolution and its impact on society at the time of Darwin. Develop a scenario where visitors from one group must find out and respond to the views held by the other.

14.11 Computers

In countries such as Australia, Britain, Canada, Sweden and the United States microcomputers are now well-established at all levels of the educational system (15). There is strong evidence to suggest that this trend will continue and will not be just another temporary educational "fashion" such as was the case with programmed learning in the 1960s. The difference between computer education and programmed learning is that pressure for the introduction of computers has come mainly from the community. Many homes now have personal computers, printers and an appropriate range of software. Parents perceive obvious economies in time and effort in using techniques such as word processing, managing data-bases, and in using computer graphics, spreadsheets and computer models and simulations. They therefore encourage schools to obtain and use computers.

In Australia almost all primary schools have at least one or two microcomputers and most secondary schools have computer rooms for entire classes. Personal and other types of more advanced computers are also available in all tertiary institutions. This has become economically possible because of falling prices. A personal microcomputer with printer can be purchased for little more than the cost of a colour television receiver.

It is important to distinguish between two forms of software for microcomputers. The first type is "productivity" or "tool" software of the kind already mentioned above - word processing, spreadsheets, computer graphics and so on. This type of software is concerned with planning and production techniques which apply to any area including administration and the production of resources. The second type is pedagogical which at present is relatively limited in scope but new programmes are being released all the time.

A recent catalogue (1986) published by one biological supply firm in Australia lists the following pedagogical software for use with one type of microcomputer - the Apple II. This list is reproduced with the kind permission of Southern Biological Services Pty Ltd, PO Box 57, Nunawading, Victoria 3131, Australia.

> Microcomputer Software for the Apple II
>
> Catlab: Genetic simulation that allows students to mate domestic cats selected by coat colour and pattern to produce a genetically valid litter of kittens. The package enables students to test and refine scientific hypotheses, and can be used with either B/W or colour display. Package contains student's guide, instructor guide, set of 8 slides, and software on diskette.
>
> Catgen: Differs significantly from Catlab in that Catlab allows the students to control phenotypes while Catgen allows control of genotypes. The two packages are designed to complement each other in the study of transmission genetics.

Birdbreed. Flexible programme which investigates genetic principles of colour inheritance in budgerigars, viz. four increasing levels of comprehension. Genetic concepts such as monohybrid inheritance, sex linkage, gene interaction, etc. are examined. Programme can be used with either B/W or colour display. Package contains teacher's guide, student guide and software on diskette.

Gene Machine. First part of programme allows for interactive investigation of bases in DNA and RNA. Second section allows students to enter in RNA codons and to synthesize a polypeptide chain. Programme can be used with either B/W or colour display. Package contains teacher's guide and software on diskette.

Heredity Dog. Suitable for use at both junior and senior levels. A tutorial section is included in the programme in addition to five single gene and five two-gene simulations. Phenotypes or parents and offspring are displayed in colour as well as allele symbols representing their genotypes. Package contains teacher's guide and software on diskette.

Human Genetics. Programme allows students to explore inheritance of Huntington disease, an autosomal dominant trait; thallassemia, an autosomal recessive trait; haemophilia, an X-linked trait; and ABO blood type, an autosomal trait based on multiple alleles. Package contains teacher's guide and software on diskette.

Human Pedigree. Programme is based on inheritance of a bank of 25 genetic disorders including cystic fibrosis, muscular dystrophy, phenyl ketonuria, etc. Computer-generated pedigrees are shown and the student is asked to deduce the pattern of inheritance. Students are given feedback on the correctness of their choice and the unknown disease is then identified. Package contains teacher's guide and software on diskette.

Choles. Programme incorporates a data base of cholesterol content of nearly 250 Australian foods, including take-away foods. Users can check cholesterol content of a food and enter a diet for analysis. After entry, diets may be modified by addition or deletion of food items. Package contains teacher's guide and software on diskette.

Bioquiz TF. A resource of approximately 200 true/false biology items organized into a number of topics. Students can select up to ten questions on the one topic or across a range of topics.

Bioquiz MC. A resource of approximately 100 multiple choice biology items organized into a number of topics. Students can select up to ten questions on the one topic or across a range of topics. Each question contains four alternatives.

Note that these topics include (i) genetics (ii) a quantitative aspect of human nutrition and (iii) test quizzes. On the whole these represent examples of drill and practice software. It is important to understand, however, that there are now available materials which deal with more advanced concepts, problem solving situations, simulations, experimental design and so on. Some of the best of these include group activities and challenge learners to think about issues of social concern (16).

An important aspect of the introduction of computers is that both teachers and pupils must develop competency in what has come to be termed "computer literacy". Computer literacy involves two categories of skill - how to use the computer and the basic skills of programming. Not all students may need to write programmes, but certainly the biology teacher of the future must face up to this challenge. Commercial programmes of both "tool" and "pedagogical" types may need to be adapted for the needs of particular teaching situations or new programmes may need to be developed from first principles. In particular tool type programmes originally developed for the business world have enormous potential in education provided they are suitably modified.

In conclusion, then, while at present microcomputers in schools are to be found mainly in the more affluent countries, this situation is bound to change. There are two reasons for this. The first is the continuing fall in price which enables computers to be bought without excessive expenditure. The second is the cost-effectiveness of computers. Their versatility enables them to subsume and streamline many procedural functions such as typing, printing, planning, data retrieval, production of learning resources and so on. In addition, their potential for extending the options available for creative learning is immense and schools which do not explore this potential inevitably must be disadvantaged.

14.12 Conclusion

In the development of this chapter there have been four recurring themes. These are summarised below.

(a) Improvisation

The best educational resources are those which are most relevant to the achievement of course objectives. Frequently it is the learning materials, sometimes even equipment, which is made cooperatively by teachers and students which are the most educationally effective. Some teachers tend to choose high cost commercially produced equipment and learning materials in the belief that an alternative is giving students "second best". This is certainly not the case in resources for socially relevant biology. Materials produced to meet specific learning situations as they arise are certain to be "on target". Since most of the situations reviewed in socially oriented programmes are local and arise from local needs it is unlikely that appropriate commercial resources would be available anyway and so improvisation is the only alternative.

Unesco has produced several useful publications on the improvisation of learning resources. Some of these are listed in the notes and references at the end of this chapter (17).

(b) Flexibility

Resources for socially relevant biology should be multipurpose. Highly specialized science equipment is generally not required and only a basic range of audiovisual hardware is needed. What is required is the opportunity to utilize the real world, real objects and real situations. Consumables are probably more important than a lot of expensive equipment. On the purely science side these would include the chemicals, stains, specimens and so on needed to study the science base of any issue under consideration. On the audiovisual side what is especially needed is a range of production facilities such as drawing instruments, colours, papers, film, transparencies, tapes and so on so that relevant materials can be effectively and quickly produced. In the library there should be lots of pupil and teacher made resources and magazines, newspapers and other low cost materials relevant to a wide range of current social issues.

(c) Community Involvement

Resources outside the school are reviewed in the next chapter but since socially oriented biology is concerned with community matters close liaison with local institutions and individuals in the development of school resources is important. The most significant of these is probably help which can be provided by parents as teachers' aides and in helping with the production of resource materials through the provision of funds, by donating materials or through assisting in production workshops.

Community drives to raise money and material resources for the school are also important and are likely to be successful if local people perceive that the focus of the curriculum is on local needs and concerns. Also as social issues are investigated, local personalities involved in particular issues can be invited to visit the school to give talks, to be interviewed by students or to make tape recordings of statements and points of view.

(d) Relationship Between Scientific and Social Elements

In the acquisition, development and management of resources for socially oriented biology both the scientific and societal components must be catered for. It should never be overlooked that the programme is based in science and while it is the applied aspects which should receive most attention, nevertheless scientific as well as social studies type resources are needed. This is particularly true for the biology laboratory and classroom. While expensive specialized equipment is probably not needed a full range of basic resources for the teachers of biology is essential. A change-over from conventional to socially oriented biology should not be an excuse for reducing the budget and in fact is likely to be more expensive.

Notes and References

(1) Much of the material in this chapter is based on the following source.
Meyer, G. Rex Overcoming Constraints on the Teaching of Biology A Global Perspective. Jakarta: Unesco Regional office for Science and Technology in South East Asia 1988 pp 117-133.

(2) Meyer, G. Rex Alternative Strategies including Methodologies for Learning-Teaching of Biology at School Level for Relevance and Appropriate Skill Development for Everyday Life (Science and Technology Education Document Series No 2). Paris: Unesco 1982.

(3) At present accounts of the design and layout of biology classrooms and laboratories tend to focus on the needs of the conventional type programme with little reference to the additional and special needs of the socially oriented approach. Nevertheless the following references provide some useful ideas, mainly on the science side.
Unesco: Unesco Handbook for Biology Teachers in Africa. Paris: Unesco 1986, especially pp 199-210. The layout given in figure 27 p 27 is very suitable for the socially oriented approach.
The following references give helpful technical details but need to be used with more recent developments in mind.
Guy, K. Laboratory Organization and Administration. London: Macmillan 1962 386 pp.
Savage, Sir Graham The Planning and Equipment of School Science Blocks. London: John Murray 1964 78 pp.

(4) See for example
Unesco: Unesco Source Book for Science Teaching. Paris: Unesco 1956 222 pp.
Unesco: New Unesco Source Book for Science Teaching. Paris: Unesco 1973 270 pp.

(5) Science Teaching Center University of Maryland Guidebook to Constructing Inexpensive Science Teaching Equipment Volume I: Biology. College Park: University of Maryland Science Teaching Center 1972 288 pp.

(6) Unesco Handbook for Biology Teachers in Africa op.cit. note (3).

(7) New Unesco Source Book for Science Teaching op.cit. note (4) pp 145-178.

(8) For a useful account of developing and managing a multi-media library see Hicks, Warren B. and Tillin, Alma M. *Developing Multi-Media Libraries*. New York: R.R. Bowker, 1970 199 pp.

(9) Comprehensive criteria and checklists for the evaluation of the suitability and effectiveness of biology textbooks are provided in the following source:
Unesco: *Unesco Handbook for Biology Teachers in Asia*. Paris: Unesco 1986 pp 576-587.

(10) The various Unesco Source Books and Regional Handbooks contain helpful information which could form the basis for this part of the teacher's guide.

(11) For technical aspects of the use of audiovisuals in biology see the following:
Unesco: *New Trends in the Utilization of Educational Technology for Science Education*. Paris: The Unesco Press 1974 248 pp.

(12) Several useful resources are available in this area. The following are especially recommended:
Ellington, Henry; Addinall, Eric; and Percival, Fred *Games and Simulations in Science Teaching*. London: Kogan Page 1981 216 pp.
Gibbs, G.I. (Ed) *Handbook of Games and Simulation Exercises*. London: E. and F.N. Spon 1974 226 pp.
Gordon, Alice Kaplan *Games for Growth Educational Games in the Classroom*. Chicago: SRA Science Research Associates 1972 206 pp.
Hounshell, Paul B. and Trollinger, Ira R. *Games for the Science Classroom an Annotated Bibliography*. Washington DC: National Science Teachers Association 1977 246 pp.
Lehmann, Jürgen and Schilke, Karl "Games and Simulations in Biology Teaching" *in* Unesco: *New Trends in Biology Teaching Volume V*. Paris: Unesco 1987 pp 75-101.

(13) Based on the following source:
Meyer, G. Rex *Strategies for Improving the Social Effectiveness of Biological Education at School Level - with Special Reference to Innovative Methods of Teaching* (ISMED Occasional Paper No 4). Quezon City Philippines: Institute for Science and Mathematics Education Development University of the Philippines (ISMED) November 1983 pp 9-10.

(14) *Ibid* pp 10-11.

(15) See especially
Crovello, Theodore J. (Ed) *Computers and Biological Education The Expanding Universe Presentations Made at a Workshop Organized by the IUBS Commission for Biological Education 3-5 September, 1986, Helsinki, Finland*. Paris: The International Union of Biological Sciences 1988 178 pp.

(16) *Ibid*. See especially pp 61-72.

(17) The Unesco Regional Handbooks for Biology Teachers (*op.cit*. notes 3 and 9) and the Source Books for Science Teaching (*op.cit*. note 4) are especially recommended for guidelines on the improvisation of low cost materials and other resources. In addition the following publications of the Unesco Regional Office for Asia and the Pacific (Unesco Roeap) Bangkok should be useful.

Unesco Asian Programme of Educational Innovation for Development (APEID). Bangkok: Unesco Roeap.

- *Design, Development and Evaluation of Low-Cost Educational Materials Report of a Regional Workshop Kuala Lumpur, 5-15 December 1977*

- *Low Cost Educational Materials How to Make How to Use How to Adapt:*
  - *Inventory Volume I* 1980
  - *Inventory Volume II* 1982
  - *Inventory Volume III* 1984

Chapter 15

FACILITIES AND RESOURCES OUTSIDE THE SCHOOL

15.1 Introduction

Resources of the community play an important role in programmes of socially oriented biology. Reference to the exemplar content, activities and test questions given in Part II of this volume shows that much of the material is based on real-life situations in the local district.

Apart from more traditional sources such as museums, zoos, botanical gardens, ecological field sites, health centres, farms and other agricultural institutions there are several other categories of community resource which should be fully exploited in achieving socially relevant objectives. These include the home; housing estates and other developmental projects; vocational and trade centres; industrial and commercial institutions; various government planning departments; community centres and public libraries; environmental sites illustrating the clash of interests between developers and conservationists; mass media outlets, retail outlets and so on.

Because of the human focus people become very important as resources for this type of approach. Surveys of opinion, interviews with protagonists, attendance and involvement in public meetings, visits to local government officials and talks with community leaders are all valuable.

Since Part II provides exemplar content and learning experiences utilizing many of these resources this chapter reviews only general principles. Some additional ideas on how community-based resources may be used are presented in the form of suggested themes for study or investigation.

15.2 Museums, Zoos and Botanical Gardens

The traditional approach to using these resources is for lessons illustrating biological concepts such as classification, evolution, adaptation and behaviour (1). At zoos studies are frequently made of evolutionary relationships between groups, primate evolution, the behaviour of mammals and adaptation of vertebrates for the life in the various biomes of the world (2). In natural history museums similar studies are made but with greater emphasis on cultural aspects such as the impact of our species on the natural environment (3). Gardens are used for studies of plant taxonomy, adaptations for life in different habitats, morphological variations and so on (4).

In a socially oriented programme these approaches do have a place but the emphasis is more on general social issues. For example what are the educational, technical, economic, development and scientific roles of these types of institutions in society? In this regard the more broadly based the institution the more useful it is. An applied science or a technological museum is more useful than a more traditional museum of natural history (5). Gardens which emphasise the economic use of plants are more relevant than those mainly for taxonomy. A zoo which considers aspects of animal husbandry, agricultural implications and conservation functions is more useful than one that merely displays taxonomic groupings of representative animals.

The administrative and scientific staff of museums, zoos and botanical gardens are very important resources for the socially oriented approach. They should be interviewed about what they perceive to be the roles of their institutions, funding aspects and the contributions made by the institutions to education and other aspects of development at personal and more general levels.

Suggested Approaches

- Reviewing the ethical and moral implications of keeping animals captive in zoos.
- Investigating the position of the animal liberation movement towards zoos.
- Analysing economic contributions made by museums, zoos and botanical gardens.
- Evaluating the research activities of these types of institutions and their significance for society.
- Investigating the role of zoos and botanical gardens in preserving endangered species and the significance of this for society.
- Writing about how ordinary families can make use of zoos, museums and botanical gardens to improve their quality of life.
- Investigating how the staff of museums, zoos and botanical gardens can make contributions to solving important social dilemmas such as conservation versus development.
- Reviewing how institutions of this type may help foster a world view amongst peoples of different countries and so contribute to a respect for others and to world peace.

- Assessing what might be lost from society if there were no museums, zoos or botanical gardens.
- Making suggestions about ways zoos, botanical gardens and museums could contribute to improvements in (i) human health (ii) crop farming (iii) animal farming (iv) preserving the natural environment.

15.3 Ecological Field Sites

For many years now schools have been encouraged to undertake ecological studies in the field and to visit forests, grasslands and other terrestrial communities, freshwater lakes and streams and marine habitats (6). The approach until recently has been fairly academic with an emphasis given to formal studies of community structure (eg. forest profiles, food chains and food webs); to distribution patterns (quadrats, transects and so on); to population studies and to ecological adaptations.

Some education authorities approach this work very thoroughly and systematically. For example the Ministry of Education of the Seychelles issues the following very helpful matrix to advise teachers on the use of field sites. The more traditional range of ecosystems is extended to include situations such as coconut plantations, agricultural plots, houses, school compounds and reclaimed land (7).

Topics Suitable for Study at
Specified Types of Field Sites
(Seychelles Ministry of Education)

Type of study	Mangrove	Mudflat/sandflat	Sandy beach	Rocky shore	Freshwater marsh	Coconut plantation	Agricultural plots	Houses	School compounds	Reclaimed land
Plant life	++		++	+	++	++	+		++	++
Animal life	++	++	+	++	++	++	+	++	+	
Detritus based habitats	++	++	+	+	+			++		
Animal behaviour	++	+	+	++	+			++		
Camouflage	++	+	+	++	+	+	+	+		
Microscope work	+	+		++	++					
Zonation	+	+	++	++	++					
Quadrat work		++	+			++			+	++

++ = Good
+ = Quite good

Techniques and methods advocated in the more conventional approaches to field work remain valid for socially oriented biology. Today, however, a greater emphasis is given to applied aspects. In the example above from the Seychelles studies of sites such as houses, plantations and reclaimed land would be very suitable for applied studies which could in fact focus on socially relevant problems.

Two recent publications by Unesco in its Science and Technology Education Document Series illustrate this point. The first is the report by Ian Spellerberg and Alan J. Pritchard Ecology Ecosystem Management and Biology Teaching (No 10 in the Unesco series) (8) and the second is the volume Use of the Sea and its Organisms by Abul K.M. Bashirullah and Molla Fazlul Huq (No 23 in the Unesco series) (9). Both these reports emphasise management and economic aspects of ecological study.

The report by Spellerberg and Pritchard stresses human ecology and reviews humankind's disruption to natural ecosystems. Ecological situations and sites recommended as resources for study include farms, economic forests, marine and freshwater systems, game reserves and other areas for wild animals. Economic and management issues for crop production, the fishing industry, logging and game conservation are reviewed. As an example of the methods which could be used for this type of study is provided using a case study of pest control in apple orchards in England (10).

The report on the use of the sea (actually the volume also refers to other types of aquatic regime) by Bashirullah and Huq also emphasises economic and management issues. There are excellent accounts, for example, of the problems of overfishing and of ecological, economic and management aspects of industries such as mariculture, mullet culture, shrimp culture, oyster farming and duck farming.

The main point about the use of ecological sites as resources for a socially oriented biology course, as in the case of experimental laboratory studies, is that scientific aspects are undertaken to understand some issue of social relevance and not for their own sake. It may be necessary to make studies of numbers and of patterns of distribution and of the environmental factors which determine them. But such studies would be in order to investigate issues such as the problems of pollution; overcropping or overfishing; economic viability and optimal production methods.

Suggested Approaches

- Undertaking an ecological investigation of claims of overfishing in a particular aquatic industry.

- Studying the extent of chemical pollution in the water supply of a community.

- Investigating incidence and control of insect pests on a farm producing a commercial crop such as fruit or grain.

- Comparing well managed and neglected (abandoned) stands of a commercial crop - eg. wheat, sugar cane, beet etc.

- Evaluating the ecological accuracy of arguments for and against logging in a given stand of natural forest.

- Studying the ecological basis of the health and economic conditions of workers in a labour intensive agricultural industry such as tea or rice production.

- Appraising the economic viability of selected "old style" local crops such as raffia, tobacco, sisal (agave) or kapok.

- Seeking fuel alternatives for villagers destroying local forests for firewood.

- Measuring the decline in diversity of intertidal marine organisms due to pollution from local seashore industries (eg. oil refinery).

- Studying changing patterns of distribution and numbers of selected mammals in a game park due to poaching.

15.4 Sites for the Study of Socially Sensitive Environmental Proposals

An extension of the ecological approach suggested in Section 15.3 above involves utilizing the sites of planning proposals which may enhance or degrade the quality of the environment. Such sites are valuable resources for socially oriented programmes and should be exploited to the full (11). Again, however, the scientific bases of the issues involved should be investigated using ecological and other relevant techniques.

Any secondary school, whether urban or rural and whether in the developed or developing world, is almost certainly located near some kind of planned project which will have an impact on the quality of the environment. The following list suggests just a few of the possibilities.

Widening a local highway
Building a pontoon bridge across a lake
Replacing bushland with a new housing estate
Building an expressway
Cutting timber from a local native forest
Building a dam across a river valley

Draining swampland for an industrial park
Building high rise office blocks in the inner city

Increasing the land area of a national park
Establishing a free range zoo in a rural area
Building an advisory centre for local farmers
Establishing a public hospital in a rural district
Establishing a new urban recreation park
Implementing a tree planting programme along a river bank
Adding a new wing to a local museum of natural history
Building a public swimming pool for local residents

Each of these types of situations is a resource for teaching about the application of biological principles in the development and implementation of local planning proposals. All have implications for the quality of the environment and for the general wellbeing of local residents. The fact that the developments are local illustrates the point that the curriculum for socially relevant biology should be sufficiently flexible to allow a choice of appropriate case studies.

Suggested Approaches

- Conducting an environmental impact study of a developmental proposal (eg. a proposed freeway).
- Undertaking a case study analysis of the effect of a specific proposal (eg. such as draining swampland to build a factory complex) on the quality of life of local residents.
- Preparing and submitting to appropriate authorities a proposal to increase the area of a local national park.
- Organizing a protest movement against a local proposal (eg. to log a local natural forest).
- Completing an ecological survey of an area of local bushland which may be destroyed for development (eg. to build a housing estate).
- Surveying the health needs of a local district to provide data for a newly established community hospital.
- Organizing a local educational programme to advise local people about the need to conserve natural forests.
- Writing a series of letters to local newspapers arguing in favour of increased open space in the inner city.

- Organizing a community display presenting arguments for and against a development proposal (eg. building a local dam).

- Undertaking a survey of public opinion about a developmental issue (eg. whether or not to encourage high density housing in a specific part of the city).

15.5 The Home and Family

In Part II of this volume several examples were reviewed of utilizing aspects of the home and of family life as a resource for teaching socially relevant biology (12). Biological aspects of the home including the quality of the shelter provided and aspects of family life were reviewed. Topics about housing included the construction of houses using biological materials; the hygiene of house design - ventilation, lighting, disposal of sewage and household wastes and so on; the problem of crowding; the design of housing estates to ensure the wellbeing of residents; facilities in the home for cooking and so on. Topics about the family included family planning; the rights, roles and duties of the various members of the family and general aspects of family life. Another area covered was income generation including the use of the home garden for generating supplementary income, family budgeting and so on.

From this review it is clear that the home and the family is an important resource. There are several ways in which this resource can be utilized. In each case of course the purpose would be to investigate a particular issue or problem.

In the first place the homes and families of individual students can provide data for individual project work. Students can analyze the nutritional habits of the family, can investigate the family budget, and they can describe how the physical and hygienic aspects of the home could be improved. Students in villages or small towns could design a home garden for the purpose of raising extra money from produce. The focus of this work would be to improve the general quality of family life.

Another way the resource could be used would be to involve families in social surveys investigating aspects such as the provision of direct home services (water, electricity, drainage, garbage and sewage disposal). These surveys could seek either facts or opinions or both.

A third way in which the homes and families of students could be used as a resource is to involve family groups in school activities such as fund raising; preparation of learning materials; to help in teaching and so on.

A fourth approach is to investigate local housing more broadly on a community-wide basis (13). In this type of approach direct observations can be made of the general layout of housing estates; the quality of housing in relation to the environment; and the effectiveness of community services such as transport, retail outlets, health clinics and schools and their interrelationships.

Key aims of socially oriented biology are to foster positive personal and community development and to enhance the quality of life and general social wellbeing. The importance of utilizing the home and of the family as an educational resource cannot be over emphasised.

Suggested Approaches

- Reviewing hygiene standards of homes of individual students with suggestions for improvements.
- Analysing food budgets of representative families and suggesting ways of making cheaper and more nutritional meals.
- Conducting a survey of students' families in terms of numbers in the home; status, roles, duties and responsibilities; and resources needed for life support and education.
- Surveying family budgets and suggesting ways of increasing family income through biology-based activities such as home gardening or small animal production.
- Studying environmental aspects of local housing in terms of impact on the quality of the natural and the built environments.
- Analysing energy needs, resources and costs of typical local families. Preparation of family guidelines for saving energy.
- Reviewing community resources available to family groups in areas such as transport, power, clean water, sewage, garbage disposal and communications and preparing a development plan for improvement.
- Evaluating local development plans for improving numbers and quality of local housing estates.
- Critically analysing community wide resources for local families in areas such as retail outlets, health services, education, family counselling, recreation and sport with suggestions for improvement.
- Organizing an educational programme for local families on family planning.

15.6 Secondary Industrial and Commercial Institutions

There are several reasons why local secondary industries and commercial institutions are useful resources for socially oriented biology. The first is that they frequently illustrate technological applications and so provide insight into the complex relationships between science and technology in the development of the national economy.

A second reason for studying industrial and commercial institutions is that they are likely employers of school leavers and so there are vocational implications in visiting and understanding their processes, procedures and products.

A third reason is that frequently such institutions are the centre of local issues which provide case studies of the relationships between biology and society. For example the problem of the disposal of wastes from, say, a chemical plant, or the nutritional value and cost of food products being marketed by local supermarkets or village shops.

A fourth reason for using these institutions is that the owners, managers and employees are members of the same general community as the school, its students and the families of the students. They are components in the complex web of interrelationships which constitutes the community as a whole. Their roles, needs and contributions therefore require examination from the point of view of human ecology (14).

A school which emphasises social issues must establish good working relationships with all types of community agencies including industrial and commercial institutions. Such institutions are of course vital in any programme of work experience (see Section 15.9 below) but are also important as sources of data for social surveys, as sites for visits to study technology and retail processes and as sources of money, materials and expertize to support the school curriculum. Tactful and sensitive liaison between the school and these institutions is therefore of paramount importance.

Suggested Approaches

- Surveying the consumer needs of local families and matching them against the types of retail outlets in the local shopping centre. Comparisons made between the local human community and a natural community of plants and animals in terms of needs, energy supply, interrelationships and so on.

- Studying the impact of a selected local secondary industry on the quality of the natural environment.

- Analysing inputs, processes and outputs of a local biologically-based industrial institution or factory (eg.

food processing, manufacturing pharmaceuticals or timber processing).

- Surveying attitudes of industrial managers towards the impact of their industries on (i) the natural environment and (ii) the wellbeing of the local community.

- Surveying attitudes of residents towards the presence of defined categories of industry in the local community.

- Studying one product of a local biologically-based secondary industry (eg. canned fruit) reviewing (i) source of raw materials (ii) manufacturing processes (iii) quality control (iv) distribution and marketing and (v) economic impact.

- Reviewing the concept of consumerism in society by an analysis of purchasing habits of local families.

- Evaluating the basis in biological truth and effectiveness of advertising for locally available biologically-based manufactured goods such as (i) processed foods; (ii) resources for health such as drugs or dental care products; or (iii) goods manufactured from raw materials such as timber, other plant materials and animal fibres such as wool.

- Reviewing and critiquing local development plans for the expansion of biologically-based industries.

- Making a land use survey of the local area in terms of the location of residential areas;manufacturing industries of various types; commercial outlets; shopping centres; recreational facilities; community services; transport and so on from the point of view of the human ecology of the district.

15.7 Farms and Other Agricultural Institutions

Agriculture as a subject in its own right has been established for some time in many school systems. In addition most programmes of school biology have included agricultural elements or have provided a base-line of biological concepts such as plant physiology, entomology, soil science and so on necessary for agricultural studies (15).

There has been also, a growing appreciation that there should be closer and more systematic links between school science and the rural environment (16) - and some educators have advocated the introduction of a subject entitled "rural science" (17). This type of programme would include topics such as the study of a farm as an ecological unit (see Figure 15.1 below) (18).

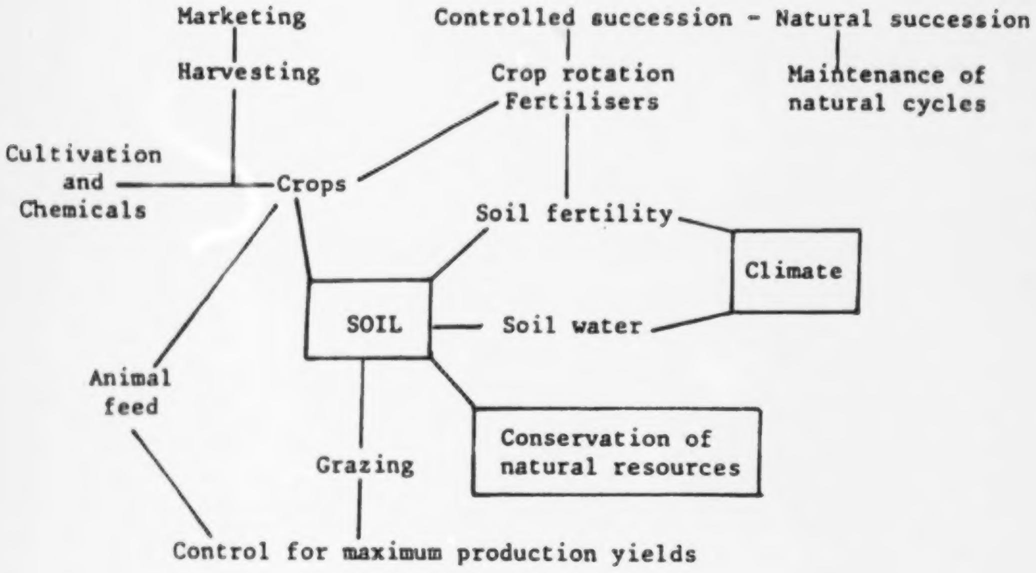
Marketing
Harvesting
Controlled succession - Natural succession
Crop rotation
Fertilisers
Maintenance of natural cycles
Cultivation and Chemicals
Crops
Soil fertility
Climate
SOIL
Soil water
Animal feed
Conservation of natural resources
Grazing
Control for maximum production yields

Figure 15.1 The Farm as an Ecological Unit (after A.N. Rao and A.J. Pritchard - see notes 14, 16 and 17).

Many of the ideas expressed by advocates of rural science programmes are relevant to courses of socially oriented biology. This is for two reasons: The first is that rural science would involve a considerable amount of applied biology and the second is that to be effective rural science would need to focus on a study of socially relevant issues.

Farms and other agricultural institutions are therefore very significant resources for biology courses with a societal focus. Issues of concern could include economic viability of certain agricultural products; environmental and nutritional impact of fertilizers and pesticides; the importance of crop rotation in maintaining the fertility of the soil; the role of agriculture in community and national development and vocational aspects of agriculture.

Visits to farms, observation of practice and interviews with farmers are therefore important aspects of the programme. In addition there should be close liaison with any agricultural extension programmes available in the community and wherever possible links should be established with agriculture research units and agricultural education centres.

Suggested Approaches

- Studying the marketing policy of a local farm to determine if financial returns could be improved.
- Investigating how farms in the local district work to preserve the fertility of the soil.
- Assessing and evaluating the use of chemical fertilizers in the local farming community and suggesting possible alternatives.
- Making an analytical review of the impact of local agriculture on the economy and social wellbeing of the district.
- Making a social survey of employment opportunities in the local agricultural industries.
- Studying the biological basis of effective farming practice in the case of a specific agricultural product.
- Making scientific comparisons between a farm and a natural community of plants and animals as ecological units.
- Examining the energy needs of a farm with recommendations for reducing energy costs.
- Reviewing the agricultural policy of the local and national governments in relation to overall economic development of the country.
- Investigating if and how farming outputs could be diversified in the local area.

15.8 Hospitals, Health Centres and Clinics

Health and hygiene are central concerns of any programme of socially oriented biology (19). Several examples of content and activities in this area were reviewed in Part II of this volume (see especially Chapter 6 Section 6.3). Hospitals, health centres, clinics, pharmaceutical manufacturers and suppliers, government health agencies and health services and individual members of the medical profession, therefore, are all important community resources for this type of programme.

Within the school itself the day-to-day content of the biology programme can frequently deal with the issue of wellness, both physical and mental, and with the healthy development of the whole person. Community resources such as those listed above can be used to (i) complement the school-based teaching and (ii) extend the study of health to cover broader social issues, some involving major policy matters. Areas such as public health services; the impact of public health education programmes on the wellbeing of the community; the level and quality of health services in the community; the patterns of supply and demand; areas of community health requiring special attention and economic aspects of public health services are just some of the areas which could be examined.

Visits to public hospitals, clinics and government health centres are important but must be carefully and responsibly organized. Hospitals and clinics are frequently understaffed and have extremely busy schedules. Visits should be planned which cause minimum disturbance to the daily routine and which intrude as little as possible into the busy schedules of medical staff. Observational checklists, interviews with patients, talks with management and with volunteer aides are all useful and are minimally intrusive. Interviews with the medical and paramedical staff should be kept to a minimum.

Data from visits should be supplemented by information obtained from relevant government reports and other official documents. Public opinion surveys could be undertaken to check on attitudes towards the coverage and quality of health services and on its economic aspects. Surveys can also be undertaken to check on public awareness of good health practice - diet, exercise, immunisation, cleanliness, dental care and so on.

A major aim in this area should be to review the quality of public health services, to identify deficiencies and to prepare submissions and suggestions aimed at upgrading the system. In this way the school biology programme takes on a very significant social role.

Suggested Approaches

- Identifying the numbers, types, characteristics, and programmes of the various local agencies responsible for community health and evaluating their impact on the wellbeing of local people.

- Undertaking a survey to identify the most commonly occurring health problems in the school district and reviewing how these problems are being addressed through local health services.

- Investigating the types of cases being treated by local health clinics and reviewing their biological basis. Suggesting possible approaches for improving the health services provided to deal with the types of cases investigated.

- Interviewing public health officers in government health education services to find out about the content, methods and impact of their programmes.

- Reviewing the work of the local district hospital in preventative health services for the community.

- Investigating the cost of medical, dental, pharmaceutical and other health services to different categories of families and suggesting how such costs could be moderated and/or more effectively budgetted.

- Using a case study approach investigating the health records of selected volunteer students and the extent to which these students have effectively and appropriately (i) used the facilities of the local health service and (ii) responded to recommended health programmes and advice.

- Investigating government priorities for improving health services nationally and locally and evaluating the government proposal in terms of local needs.

- Designing a health programme for (i) the school and (ii) the local community.

- Finding out the extent to which local health institutions benefit from (i) national programmes and funding and (ii) help and advice provided by international agencies such as the World Health Organization (WHO).

15.9 Vocational Centres and the Work Environment

School biology can assist in vocational orientation in several ways. The first is to explain the scientific basis of various biologically based areas of employment; the second is to analyze the type of work involved in various biology-based jobs and the third is to provide students with direct employment experience in biology-related occupations. Mention has been made already of the use of farms and other agricultural institutions and agencies, and of biologically-related secondary industrial and commercial institutions as resources for giving vocational training and experience. To this list could be added the community health resources discussed in the previous section and other agencies such as the mass media (Section 5.10); sporting and recreation groups and scientific institutions such as zoos, museums, research laboratories, botanical gardens, game parks, forestry agencies and so on.

In many developing countries there is available a further important resource in the form of community vocational training centres. Countries such as Bangladesh, Indonesia, Papua New Guinea and Thailand have well developed vocational centres as part of their systems of non-formal education and these too are important resources for developing vocationally oriented activities within programmes of socially oriented biology.

Well planned visits to institutions and organizations offering potential employment for school leavers helps students in the difficult transition from the world of school to the world of work. School biology can give even more direct support in this area, however, by participating in programmes of work experience (20). Work experience is best organized for pupils in the last compulsory year of schooling - in most developed countries this is school year ten. Students are placed in unpaid employment in local organizations for one or two weeks. This experience is seen to be part of the school curriculum and involves an analysis, reporting and evaluation of the experience. The advantages of work experience include giving students more realistic attitudes to the work place, enhancing personal social development and providing useful information about employment opportunities. In a socially oriented biology programme these outcomes are especially significant. In addition, however, work experience in such programmes can be a tool for investigating a social issue with vocational implications such as the potential closure of a local industry (eg. timber cutting) or determining development planning policy in regard to the future growth of industries in a given locality.

Suggested Approaches

- Participating in and evaluating two weeks of work experience in local biologically-based employment (hospital or clinic aide; labourer in food canning factory; laboratory attendant; sales assistant in food or produce store; classroom aide; assistant to science writer; farm hand; fruit picker and so on).

- Visiting a local factory manufacturing some biologically-based product (processed food; pharmaceuticals; furniture from local timber etc.). Identifying types of workers employed; describing their duties and responsibilities and assessing potential for employment after leaving school.

- Visiting a local vocational training centre for discussion with staff of the types of training provided in biology-based skills.

- Selecting a biologically-based trade or profession (eg. laboratory assistant; science journalist; forestry officer; game park or national park warden) and surveying the work conditions and career opportunities for this occupation in various categories of employment in the local district.

- Visiting government and non-government employment agencies to investigate what types of biology-based jobs are available in the district and what must be done to qualify for those jobs.

- Selecting one type of professional employment in biology such as the medical or paramedical profession; agricultural scientist; research scientist; veterinarian; forester; dentist; science writer and so on and investigating the following aspects (i) on what areas and concepts of biology is the employment based (ii) what training is required (iii) what are the career opportunities.

- Interviewing selected local people successfully working in a range of biologically-based jobs to review attitudes to their employment and to find out how training in biology helped or would have helped in their day-to-day tasks.
- Visiting self employed local people making a living from small businesses with some links with biology (eg. market gardening; craft work based on biological products such as shell or straw; horticulture; retailing of biological products - grain, crafts; mixed farming). Investigating (i) tasks involved (ii) work satisfaction (iii) economic aspects (iv) skills and training required (v) future prospects.
- After visiting a range of employment opportunities with some relationship to biology organizing a careers evening for students and parents on categories of potential employment, the training needed for the various jobs, career opportunities and economic aspects.
- Selecting mentors from the local community with each student assigned one mentor to work with informally for several weeks or months as a pseudo-apprentice in some employment area related to biology. Students to evaluate their experiences and exchange reports during a careers symposium.

15.10 Mass Media

For many years more effective programmes of school biology have made use of information provided by newspapers, magazines, broadcast radio and television. Some educational systems have designed and presented programmes especially to support the school curriculum. Schools also make use of government and other programmes promoting health, child welfare, agricultural practice and so on (21). The importance of this type of resource within the school has been mentioned in the previous chapter (Sections 14.6 and 14.9).

There are other aspects of the mass media, however, which are important in programmes of socially oriented biology. The first of these is to consider how the various mass media institutions function including how they produce their materials and programmes. This approach involves visits to various media producers to observe production methods and it also involves practical work in the design, development and production of learning resources. Many community organizations offer schools help in this area. For example, in Australia, one of the leading newspapers, The Sydney Morning Herald, produces a low cost kit for schools which trains students in the methods of designing and laying out the front page of a daily paper (22). These types of activities achieve important educational aims including (i) developing transferable skills with vocational implications (ii) developing understanding of how various mass media are produced and function in society and (iii) providing useful learning materials for the school library.

A second aspect is to investigate the impact of specific media programmes on society. Issues of bias in reporting could be studied; public opinion surveys made of attitudes to specific programmes; the relative popularity of certain types of programme or story could be reviewed; comparative studies could be made of the interest shown and aroused by various topics in biology and so on.

A third aspect could be an investigation of economic aspects of the mass media. Central to this type of study could be an investigation of the economies, ethics and and impact of advertising. The costs to consumers of all aspects of mass media could be investigated and cost benefits assessed.

A fourth approach is to study the overall impact of the mass media on society. For example to consider whether or not broadcast television is a positive or negative influence or to check on claims that in most developed countries all media, including reading materials, are more widely used since the advent of television than before (23).

Such studies place the mass media within the framework of human ecology. They deal with the media not only as useful sources of information for biology lessons, important though that may be, but as social phenomena.

Suggested Approaches

- Analyzing the frequency and types of biology programmes or stories on television or radio or in newspapers, including assessment of their likely impact on the community.

- Visiting mass media production centres to study and later apply production techniques for preparing learning materials for the school library.

- Studying and critically evaluating how the mass media deal with a specific sensitive social issue with some basis in biology (eg. withdrawal of life support from a terminally ill patient).

- Conducting a public opinion survey of the levels of interest shown in specific programmes with biological themes.

- Investigating the scientific accuracy of advertising claims in regard to certain biological products such as canned food, cosmetics or pet care products.

- Investigating the habits of local people in regard to time spent on (i) reading books (ii) reading newspapers or magazines (iii) going to the cinema (iv) listening to records, audio tapes and compact discs (v) listening to the radio (vi) watching broadcast television (vii) watching video taped programmes. Assessing the potential educational impact of these various types of media in regard to increasing biological awareness and understanding.

- Investigating the self imposed and government standards applied to the mass media in regard to (i) accuracy of information presented (ii) violence (iii) explicit sex (iv) prejudice against minorities (v) sexism (vi) racism. Evaluating the extent to which the standards are adhered to and preparing recommendations for improvement.

- Studying economic aspects of the mass media such as investigating the comparative cost of researching and producing a programme or story on a specific biological topic for newspapers, radio and television. Analyzing relative cost effectiveness.

- Preparing articles for publication in the local press on biologically-based social issues.

- Investigating the extent to which important new discoveries in biology are transmitted speedily and accurately to the general public through the various forms of mass media.

15.11 Community Centres, Learning and Reading Centres and Public Libraries

Many countries have established community centres as part of their adult system of non-formal education. Sometimes these take the form of basic literacy centres, others offer post literacy and vocational programmes and others provide a range of reading materials at several levels to encourage neoliterates to continue to learn. In developing countries these centres are located in towns and villages and in the suburbs of large cities (24). In most countries, and especially the developed world, there is usually a network of public libraries serving the information of the community at large. These types of agencies, while mainly for adults, are also frequently "family" oriented. Whatever form they may take and whatever specific target they may have been established to serve, such centres are important resources for socially oriented biology.

Public libraries, of course, apart from just providing a book service, have tended to function as well as meeting and educational centres offering workshops, training courses, symposia, displays, venues for public meetings and so on. They frequently cater for family groups and for special interest groups and so could be useful as both direct and indirect resources for school biology.

In developing countries it is frequently the non-formal educational centres such as community learning and reading centres which become the focus of much village or district activity. If such centres can be involved in the work of the local secondary school and if the secondary school can be involved in the work of the centres there is much to be gained on either side.

Within programmes of socially oriented biology materials can be prepared by the school for use by the centres on issues of biological significance such as health, family planning or conservation of the environment. Students learn as they produce and the centres build up science resources for teaching and training.

On the other side the school can utilize the resources of the centres for social surveys, for checking on public opinion and for marshalling human resources to solve local problems. The clients of the centres benefit from this work by seeing issues in a broader social context.

Suggested Approaches

- Identifying the learning resource needs of a local adult educational centre on biological themes such as family hygiene, family planning or vaccination programmes and preparing and supplying reading and display materials for use by the centre.

- Organizing a seminar for local family groups at the public library on the biological basis of an issue of public concern such as whether or not to build a new school on an area of attractive bushland.

- Involving the adults of a local learning centre in a survey of attitudes towards a newly proposed government initiative such as a new public health programme.

- Working cooperatively with the staff of a local education centre undertaking a survey of the educational needs in the area of biology of the adult community and preparing course guidelines for use by the centre.

- Analyzing the impact of the biologically-based programmes of local adult education centres on the wellbeing of the community.

- Setting up and participating in a permanent liaison committee between local education centres and the school to foster activities for both.

- Preparing a proposal for local and/or national authorities for the establishment of a learning centre for adults to work cooperatively with the school.

- Working as voluntary tutors in basic functional literacy programmes of the local educational centres.
- Reviewing the public library holdings of books relevant to the school biology course and recommending the purchase of additional volumes.
- Working physically with the staff and members of a local adult community centre to build and maintain a cooperative unit for producing and selling goods such as vegetables, or horticultural products.

15.12 Sporting and Recreational Facilities

Almost all communities have facilities for leisure activities. Some leisure activities may be active (vigorous sports) or passive (reading or watching television). Leisure can be unsystematic and ad hoc (going for a walk or enjoying a picnic) or can be highly organized (joining a sports or hobby club) (25). The community resources and facilities available for sport and other forms of recreation are also useful as resources for the teaching of socially oriented biology.

Members of sports clubs are from one group which can assist in the teaching of biology. Studies can be made of health aspects of sport, the physiology of exercise and the role of sport and exercise in maintaining community wellbeing. Many hobbies have biological aspects - stamp collecting, bird watching, bush walking, caving, insect collecting, drawing and painting, creative writing and craft work are just some examples. Involvement with such groups can provide useful inputs for analysing social problems and for assembling learning resources.

Environmental aspects of sporting and other out-of-doors recreational activities have both local and more general implications and frequently provide useful case studies for the socially oriented approach to biology. For example in Australia some years ago there was a major community debate about whether or not a large sports stadium should be built in a public park. Other controversies surround issues such as the impact of tourism on the integrity of wild life reserves or the extent to which surfing is endangered by the pollution of city beaches from sewerage outfalls.

The overall social need for biologically based recreational activities, including sports, could be investigated. Some attempt could be made to assess supply and demand and to recommend to government and other authorities how services could be improved.

Suggested Approaches

- Investigating the extent to which local natural history resources, game parks, botanical gardens and similar facilities are used for recreation and surveying management policies intended to ensure adequate protection for the plants and animals.
- Surveying the types and numbers of sporting clubs in the local district and assessing their impact on the mental and physical wellbeing of the local community.
- Involving members of a local sporting club in studies of the physiology of exercise and developing guidelines for the community on the importance of exercise in maintaining good health.
- Cataloguing the types and numbers of biology-linked hobby groups in the community involving their members in the production of learning resources, field work and societally based activities for the school biology programme.
- Identifying and reviewing areas of immediate or potential community conflict in relation to the development of sports-fields or other recreational facilities in environmentally sensitive locations.
- Surveying and assessing the recreational needs of the community and the extent to which the present provision of recreational facilities meets those needs. Recommending positive action to improve the situation.
- Undertaking a social survey of the forms of recreation and time given to recreational activities among various categories of local people. Designing public relations programmes to promote healthy recreation and to foster the growth of recreational provision.
- Surveying the sporting and recreational interests of the school population and investigating how some knowledge and understanding of biology could enhance performance and involvement in these areas of interest.
- Organizing and participating in a school camp programme in a recreational area away from the school to (i) promote personal and social development and (ii) investigate local issues of environmental concern.
- Examining local and national government policy and priorities in regard to the development of sporting and other recreational facilities nationwide and recommending ways to enhance local implementation.

15.13 Government Agencies and Instrumentalities

Apart from agencies established by ministries or departments of agriculture, education and health mentioned in previous sections of this chapter there are many government agencies and instrumentalities which can provide resources for the teaching of socially oriented biology (26).

The police are an especially important resource since they conduct community education programmes in areas such as traffic control, public safety and drug abuse. They can be involved in cooperative programmes. In most countries the military is usually well established. Military groups can be very helpful by helping schools with material resources such as transport and training facilities and can also become involved in development tasks and opinion surveys.

Other government agencies such as housing and community planning authorities; the departments of rail, water and motor transport; the communication agencies; welfare authorities and so on can all work cooperatively with a programme of school-based socially oriented biology. Many of these agencies are concerned with aspects of human ecology, general human wellbeing, a balanced use of the environment and the utilization of energy and other resources. They can therefore help with the identification and analysis of socially sensitive biology-based issues.

Suggested Approaches

- Working closely with the local police designing and implementing an educational programme to promote (i) road safety or (ii) decreased use of illegal drugs.

- Investigating the training methods of local military groups and involving military personnel in designing resource materials for the socially oriented biology programme.

- Interviewing staff of the local department of road transport in regard to their developmental plans for upgrading the local road systems and the impact this is likely to have on the integrity of the natural environment.

- Designing a series of postage stamps on biological themes for consideration by the postal authorities.

- Investigating the waste disposal policies of the local authorities responsible for disposal of garbage, sewage and industrial waste and making recommendations for improvement in regard to environmental criteria.

- Studying the overall development plans for the local area as proposed by the local planning authorities and assessing their potential impact on the quality of life of the local people.

- Interviewing staff of the Department of Welfare to investigate the main social concerns and problems of the local community. Categorizing the problems and identifying those with a biological basis or with biological links. Developing an action plan to alleviate the problems.

- Surveying the types and roles of various government agencies and instrumentalities in the district served by the school; identifying any aspects of their activities relevant to biology or with links to biology, and evaluating the impact of their work on the wellbeing of the local community.

- Surveying public opinion in regard to perceived strengths and weaknesses of biology based on biology linked programmes and activities offered by the various government agencies and instrumentalities and preparing a submission to the government seeking improvement in the programmes.

- Interviewing staff of government agencies involved in providing services such as water, electricity and public transport and determining their plans for future development in terms of (i) meeting local needs (ii) impact on the environment and (iii) cost. Critically evaluating the proposed developments in terms of local needs and according to the principles of sustainable development.

15.14 Traditional Practice

In developing countries there has been an imposition of western style technologies on traditional activities and procedures which have been practised for many hundreds, perhaps thousands of years. In some cases the western approach has built on and improved the traditional methods and in some cases it has been less effective or less appropriate than the system it replaced. In some cases the traditional methods have been virtually forgotten and have been lost from the culture.

Many of these practices have a biological basis and their investigation is a particularly useful and important role for school-based socially oriented biology. There are three reasons for this. The first is that sometimes traditional practice is soundly based on scientific principles and with some improvement would be more effective than the alternative western type technologies. The second is that sometimes the traditional approaches are based on unsound science and rely instead only on folklore or superstition. This situation should be understood by all concerned and unsound and and at times even dangerous practices should be discouraged. The third reason for studying traditional practice is to preserve the characteristics of the culture of which it is a component and to help give a sense of historical and cultural identity to particular ethnic groups (27).

Areas of traditional practice which could be investigated include the following: marriage customs; childbirth; family planning methods and reproductive behaviour; crop growing; animal husbandry; food storage and food processing; water purification; cooling of water and food; cooking; energy sources for the home; house construction; making furniture, house fittings and utensils; transport; making cloth and clothing; use of drugs and herbs; medical practice; legal systems; justice systems and so on.

Traditional practice therefore is not only a valuable resource for the teaching of socially oriented biology. Its study becomes an imperative for ensuring the preservation of cultural mores and for selecting and blending the best of the past with the most relevant of present technologies to ensure appropriate future development.

Suggested Approaches

- Investigating and describing local procedures for storing and preserving grain and fruits and in view of modern alternatives suggesting methods of improvement to minimize (i) access of vermin (ii) growth of moulds (iii) deterioration in nutritional value.

- Surveying local customs and beliefs in regard to the human reproductive cycle and identifying those elements based on sound scientific principles and those based on misunderstanding or superstition. Developing a tactful education programme to reduce dependence on unsubstantiated folklore.

- Studying the traditional materials and methods used locally for the construction of houses and suggesting how modern materials and methods could be used to replace or complement traditional practice without compromising the best qualities of the traditional house.

- Surveying local attitudes to developments in the local district such as the construction of housing estates and the introduction of mechanized farming. Suggesting policies for blending the best of traditional and modern practice.

- Studying the traditional methods of obtaining clean drinking water and evaluating their effectiveness in terms of health and hygiene. Suggesting low cost alternatives.

- Studying the energy requirements of local family homes, investigating the efficiency of traditional sources of energy and suggesting ways to conserve energy.

- Studying local medical practice and identifying those based on sound scientific principles and those based on unfounded beliefs. Suggesting appropriate alternative procedures.

- Surveying traditional crop farming procedures and assessing their impact on conservation and fertility of the soil. Suggesting how modern farming procedures could be introduced to improve production without introducing large scale mechanization or the extensive use of chemical fertilizers.

- Reviewing traditional methods for the disposal of sewage and household wastes and assessing their appropriateness in terms of family and public hygiene. Suggesting improved alternatives.

- Studying traditional crafts such as basket work, rug making, furniture construction and so on and assessing (i) their appropriateness for local needs and (ii) their economic viability.

15.15 Conclusion

This chapter has attempted to demonstrate that for socially oriented biology the community as a whole is an important resource. Good school and community relations are essential for the success of this type of programme. The establishment of effective and continuing links with the community require tact and sensitivity. Teachers and administrators could not go far wrong, however, if they followed the excellent guidelines proposed by E. Horsch of Kelly Walsh High School, Casper, Wyoming USA (28). These guidelines are reproduced below.

GUIDELINES FOR ESTABLISHING EFFECTIVE SCHOOL AND COMMUNITY RELATIONSHIPS

(After E. Horsch)

- Establish working relationships with the community. Using the expertise of the community for information, for review of research methods and results and for drawing conclusions increases the scope of the course. It also ensures a broad base of community support.

- Make a genuine commitment to openness. It is necessary to deal openly and honestly with community goals, students' values, teachers' biases, and the goals and methods of the study.

- Ensure balanced coverage of all aspects of the topic. Select speakers, articles, and methods of investigation to present as many different views as possible. Be prepared, however, for students who find this approach to science frustrating. Accustomed as they are to equations that balance, and pigs with exactly four legs and no more, they are likely to demand the "right answer".

- Avoid controversy for the sake of controversy. The project the students choose to work on must have scientific and social merit, and its aim must be reasonably attainable. If the economic or social facts of life make it futile to address the question, forget it.

- Use established channels and participate in the formal political process to effect change. The ability to participate effectively is an invaluable lifetime skill.

- Let the students' interest dictate the topic. The teacher must be able to work with students informally and be willing to learn with and from them to be a facilitator rather than a dictator, to ask questions, to work in an unstructured situation and to be sensitive to the students and the community. Most important, the teacher must be able to work without a textbook.

- Be prepared to spend vast amounts of time and energy for seemingly minimal results. A student said it all: "We set out to go to the moon and only got a block from home."

- On the other hand, be prepared for former students who say "This is the only class I ever had that I remember!"

Apart from the immediate relevance of community liaison for achieving the objectives of a socially oriented programme of school biology there is another very important reason for promoting links between the school and the community. This reason is to foster the development of a learning society.

According to the well known Unesco manifesto of 1972 Learning to Be (29) an ultimate goal of education is for all instrumentalities of society to function as educational agencies. When that happens the society as a whole will be a "learning society" and education for all will be lifelong. In this way development will be based on the informed and rational decisions of the people as a whole and will not be left to a few technocrats. This ideal would ensure that true needs of the community and of the environment are met and that sustainable development and a high quality of life for all would be assured. A society would emerge concerned with the wellbeing of all citizens.

In achieving this ideal the school has a key role (30). The approaches suggested in this chapter have the important effect of involving a broad range of community agencies in the educational process which would not otherwise perceive their functions to be educational. In this way significant progress is achieved towards the goal of a learning society.

Notes and References

(1) Rao, A.N. *et al*. "Out of School Biology Activities in Singapore" *in* Meyer, G. Rex and Rao, A.N. *Teaching Science Out-of-School with Special Reference to Biology*. Singapore: International Union of Biological Sciences Commission for Biological Education 1984 pp 109-126

(2) *Ibid*. pp 121-124

(3) Skates, Anne "Current Trends in Museum Education in Biology" *in* Meyer, G. Rex (Ed) *Selected Issues in Biological Education Papers Submitted to an International Seminar Organized in Macquarie University Sydney 1988 by the Commission for Biological Education IUBS*. Hamburg: Lit for IUBS-CBE 1990 pp 87-95

(4) Taylor, Iaian E.P. and Straley, Gerald B. "The Botanical Garden - A Tool to Teach Systematics, Physiology and a Lot More" *in* Meyer, G. Rex *Ibid*. pp 83-86

(5) Macinnis, Peter "How Can a Technological Museum Facilitate the Teaching of Biology?" *in* Meyer, G. Rex *Ibid*. pp 96-103

(6) For example see:
Dowdeswell, W.H. Animal Ecology. London: Methuen 1952 207 pp
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(7) Ministry of Education Seychelles Conserving the Environment Part 2 The Seychelles Environment (Teachers resource book for school science, N.Y.S. and polytechnic environmental science). Victoria: Ministry of Education of the Seychelles 1989 p 97

(8) Spellerberg, Ian F. and Pritchard, Alan J. Ecology, Ecosystem Management and Biology Teaching (Science and Technology Education Document Series No 10). Paris: Unesco 1984 62 pp

(9) Bashirullah, Abul K. and Huq, Molla Fazlul Use of the Sea and its Organisms (Science and Technology Education Document Series No 23). Paris: Unesco 1986 215 pp

(10) A summary of this case study is given in Part II of this volume Chapter 8 Example 8.24

(11) An excellent account of the utilization of this type of resource is given in the following publication which was extensively cited in Part II of this volume:
Biological Sciences Curriculum Study (BSCS) Investigating the Human Environment: Land Use. Colorado Springs: BSCS 1984 106 pp

(12) Two sources frequently cited in the exemplars given in Part II were:
Ministry of Education Jamaica Family Life Education Project. Kingston Jamaica: Ministry of Education 1986 94 pp
Department of Education Hong Kong Guidelines on Civic Education in Schools. Hong Kong: Education Department Curriculum Development Committee 1985 111 pp

(13) For examples of this broader approach see BSCS Op. Cit note 11

(14) For guidelines on how science education can focus on community developmental problems see:
Unesco Asian Programme of Educational Innovation for Development (APEID) Science in Basic Functional Education: Philosophy, Approaches, Methods and Materials Report of a Preparatory Working Group Meeting (Seoul, Rep. of Korea, 7-12 July 1975). Bangkok: Unesco Regional Office for Education in Asia 1975 49 pp
Unesco Asian Programme of Educational Innovation and Development (APEID) Curriculum Development: Linking Science Education to Life Report of a Sub-Regional Workshop on

Designing and Developing Innovative Science Curriculum and Instructional Materials, Bangkok, 8-20 December 1980. Bangkok: Unesco Regional Office for Education in Asia and the Pacific 1981 74 pp

(15) For a useful account of agricultural courses and of the links between biology and agriculture see Rao, A.N. and Pritchard, A.J. Agriculture and Biology Teaching (Science and Technology Education Document Series No 11). Paris: Unesco 1984 64 pp

(16) For example see:
Asian Programme of Educational Innovation for Development (APEID) Linking Science Education to the Rural Environment - Some Experiences Report of a Mobile Field Operational Seminar Philippines and India, 13 August-2 September 1979. Bangkok: Unesco Regional Office for Education in Asia and Oceania 1980 77 pp

(17) Rao, A.N. and Pritchard, A.J. Op. Cit. note 14 pp 55-56

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(19) For example see:
Schaefer, G. et al. Health Education and Biology Teaching (Science and Technology Education Document Series No 12). Paris: Unesco 1984 41 pp
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Also see:
Taylor, Charles "Transfer with Easily Available Technology" in Taylor, C.A. (Ed) Science Education and Information Transfer (Science and Technology Education and Future Human Needs Vol 9). Oxford: Pergamon Press for the ICSU Press 1987 pp 23-27

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(24) Unesco Principal Regional Office for Asia and the Pacific (Unesco Proap) Appeal Training Materials for Continuing Education Personnel (ATLP-CE) Volume I Continuing Education: New Policies and Directions Draft Edition. Bangkok: Unesco Proap 1990 111 pp

(25) Rao, A.N. "Biology of Leisure" in Meyer, G. Rex and Rao, A.N. (Eds) Teaching Science Out-of-School with Special Reference to Biology. Singapore: International Union of Biological Sciences Commission for Biological Education (IUBS-CBE) 1984 pp 47-52

(26) Some useful guidelines for establishing links with community groups such as government agencies are provided in the following:
Horsch, E. "Case Studies on Local Industry" in Frazer, M.J. and Kornhauser, A. (Eds) Ethics and Social Responsibility in Science Education (Science and Technology Education and Future Human Needs Vol 2). Oxford: Pergamon Press for the ICSU Press 1986 pp 201-203

(27) For an example of this approach see:
Atchia, Michael "Problems and Prospects of Popularising Science and Technology Through Non-School Activities - Some Thoughts on the African Situation" in Meyer, G. Rex and Rao, A.N. Op. Cit. note 25 pp 53-56
For a case study see:
Tate, Takeshi "A Study in the Inclusion of Traditional Culture in the Teaching Material 'Science of Plants' with an Emphasis on Charcoal Making" in the Asian Association for Biology Education (AABE): Eleventh Asian Regional Conference in Biological Education Proceedings of the Eleventh Biennial Conference of the Asian Association for Biology Education December, 1986 Quezon City, Metro Manila Philippines. Manila: AABE 1986 pp 178-184
For a series of examples of traditional technology and their implications for the teaching of biology see:
Ministry of Education Papua New Guinea Science Traditional Technology Teachers Guide Grade 10 Unit 5. Boroko: Department of Education Papua New Guinea 1981 115 pp

(28) Horsch, E. Op. Cit. note 26 pp 202-203

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(30) See for example:
Dave, R.H. Lifelong Education and School Curriculum Interim Findings of an Exploratory Study on School Curriculum, Structures and Teacher Education in the Perspective of Lifelong Education (UIE Monograph 1). Hamburg: Unesco Institute for Education 1973 90 pp
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PART V

DESIGN AND TRAINING

Introduction to Part V

To conclude the volume,three chapters on aspects of design and training are presented. Chapter 16 briefly reviews appropriate approaches and procedures for designing and implementing a curriculum of socially oriented secondary school biology. Chapter 17 gives some suggestions for the design and production of suitable learning materials. The final chapter, Chapter 18, comments on the education of teachers - both preservice and inservice aspects being reviewed.

Clearly it is not the role of this volume to deal with general principles of curriculum design or implementation, of materials development, or of teacher education. The aim instead is to provide guidelines relevant to implementing programmes of socially oriented secondary school biology and only aspects which may assist with that are reviewed.

Overall a systems approach is advocated. In the case of curriculum development the classical steps of the systems approach should provide the framework but it is the inputs and the expected outcomes which require specific definition to cater for the socially oriented philosophy. Similarly for materials design it is the input and output aspects which must be geared to the special needs of the socially oriented approach.

The chapter on teacher education also follows systems theory in that both the preservice and inservice aspects are described in terms of the input needs, the most appropriate techniques and methods of training and the expected outcomes.

The success of this socially oriented approach naturally depends on the quality of curriculum, materials and activities, and on the expertize and commitment of teachers. In particular the programme and the teaching must be flexible and responsive. Because the programme must be sensitive to local issues of interest and concern to students and to the community the content should not be overprescribed and opportunities should be provided for alternatives and to take advantage of opportunities as they arise. This implies that the curriculum should not be rigidly structured.

The learning materials should focus mainly on processes and procedures rather than on the presentation of detailed factual content. For examples guidelines should be provided on how to undertake a case study or on how to report findings from an analysis of a social problem. The materials should also provide for developing a sound understanding of the science involved in any social issue or case study.

Teacher education programmes for this type of course should be activity centred. They should stress the importance of school and community links and should foster a flexible and creative approach to the identification and investigation of appropriate socially relevant issues. The methods of teaching advocated should include traditional biology methods but should extend beyond these to include methods previously considered to be the province of the social sciences. In particular small group work should be emphasised, especially discussion methods, and a high priority should be given to simulations, interpersonal educational games and to workshop type activities concerned with developing evaluative and problem-solving skills and with fostering critical thinking in a societal context.

Chapter 16

CURRICULUM DEVELOPMENT

16.1 Introduction: the Systems Approach

The dominant emerging world trend identified and reviewed in this volume has been to teach secondary school biology for social relevance. John Lewis, the British science educator who has done much in recent years to promote the science and society movement, represents the components of science education by the following figure (Figure 16.1) based on an idea of Norman Booth (1).

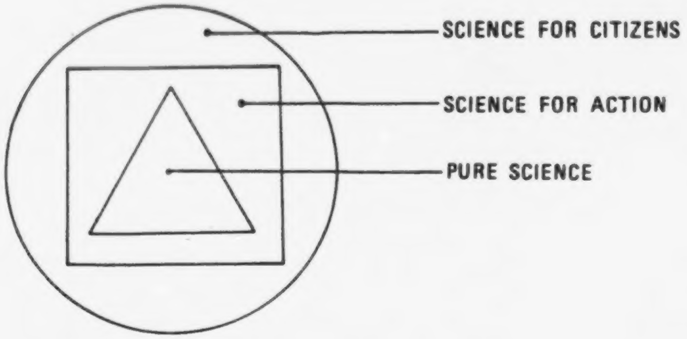

Figure 16.1: Components of Science Education
(From J.L. Lewis based on an idea by Norman Booth)

In school biology the trends of the last decade or so have moved the emphasis from pure science so that a more applied approach has emerged (science for action). There has been a further trend focussing on social issues and the application of biology in the resolution of social problems and so the overall thrust is now to develop biology courses providing science for citizens. The centre of gravity has thus shifted from the central core of pure science as shown in Figure 16.1 outwards to cater for the needs of all citizens. This has very significant implications for the design and development of biology curricula.

A systems approach to curriculum design and development is probably the most appropriate for developing a type of programme which stresses "science for action" and "science for citizens" since it allows for step-by-step planning without rigidity. Needs, objectives, processes, personnel and activities associated with specific stages of curriculum development can be identified and continuously evaluated as development proceeds (2). A general systems model is illustrated in Figure 16.2.

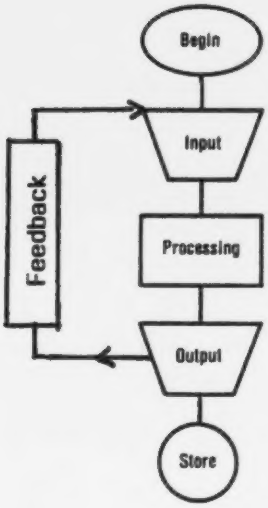

Figure 16.2. General systems model

By input is meant decisions about the needs, aims and objectives of the curriculum, by processing is meant the selection and sequencing of content and learning experiences, and by output is meant the outcomes of the curriculum in terms of achieved objectives. The feedback loop in a general systems approach is to evaluate whether the intended outcomes (output) have been achieved in relation to the inputs (needs and objectives). This then is a more refined way of expressing the systematic approach to curriculum development proposed by educators such as Ralph Tyler (3) and Hilda Taba (4). The design steps proposed by both Tyler and Taba are as follows:

Step

1: Diagnosis of needs
2: Formulation of objectives
3: Selection of content
4: Organization of content
5: Selection of learning experiences
6: Organization of learning experiences
7: Determination of what to evaluate and of the ways and means of doing it.

The ideas of the general systems model and of the steps proposed by curriculum workers such as Tyler and Taba have been brought together in a curriculum development model proposed by the present author (5). This model is illustrated in Figure 16.3.

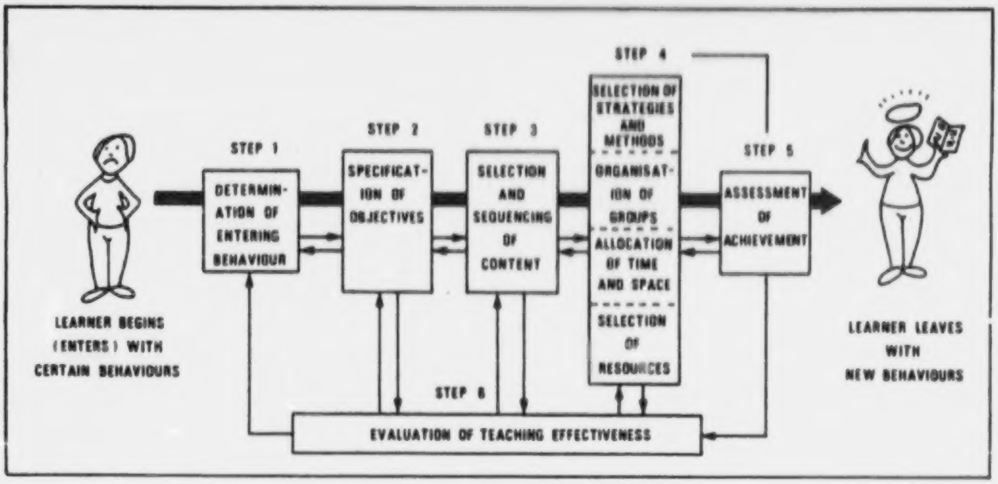
LEARNER BEGINS (ENTERS) WITH CERTAIN BEHAVIOURS
STEP 1
DETERMINATION OF ENTERING BEHAVIOUR
STEP 2
SPECIFICATION OF OBJECTIVES
STEP 3
SELECTION AND SEQUENCING OF CONTENT
STEP 4
SELECTION OF STRATEGIES AND METHODS
ORGANISATION OF GROUPS
ALLOCATION OF TIME AND SPACE
SELECTION OF RESOURCES
STEP 5
ASSESSMENT OF ACHIEVEMENT
LEARNER LEAVES WITH NEW BEHAVIOURS
STEP 6
EVALUATION OF TEACHING EFFECTIVENESS

Figure 16.3. A model for curriculum development
(After Meyer 1979)

In Figure 16.3 Step 1 (entering behaviour) is intended to indicate not only the characteristics of the learners to be catered for by the curriculum but also the needs of individuals and of the society. The interactive arrows between all steps imply that the model is totally flexible and interactive and each step must be continuously modified according to decisions made at all other steps, and in light of evaluative feedback obtained from all aspects of the system.

Another feature which marks off the Meyer approach from that of Tyler and Taba is that the model is also a representation of "presentation" steps as well as steps in course design. A well organized teacher follows the systems approach by catering for needs and characteristics of the learners, specifying lesson objectives, selecting and organizing content and activities and assessing achievement of the lesson objectives. Such a teacher is also alert to evaluate the effectiveness of such lessons. This "second level" idea in the Meyer model is suggested in Figure 16.3 by the horizontal black arrow joining the beginning student to the graduating student and passing through each step in what can now be seen to be a teaching procedure as well as a design model.

It is this systematic but flexible and interactive approach that makes the systems model so useful in the development of a biology curriculum which must cater for the rapidly changing needs and concerns of society. Also, because it compounds models for design, development, course implementation and lesson presentation it provides a framework for producing useful guidelines for curriculum workers and classroom teachers alike.

A systems model can be simplified or elaborated according to requirements (6). In the United States the general systems model

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(Figure 16.2) is elaborated in considerable detail by the Biological Sciences Curriculum Study (BSCS) as a framework for its continuing approach to curriculum renewal. This more detailed model is reproduced below as Figure 16.4.

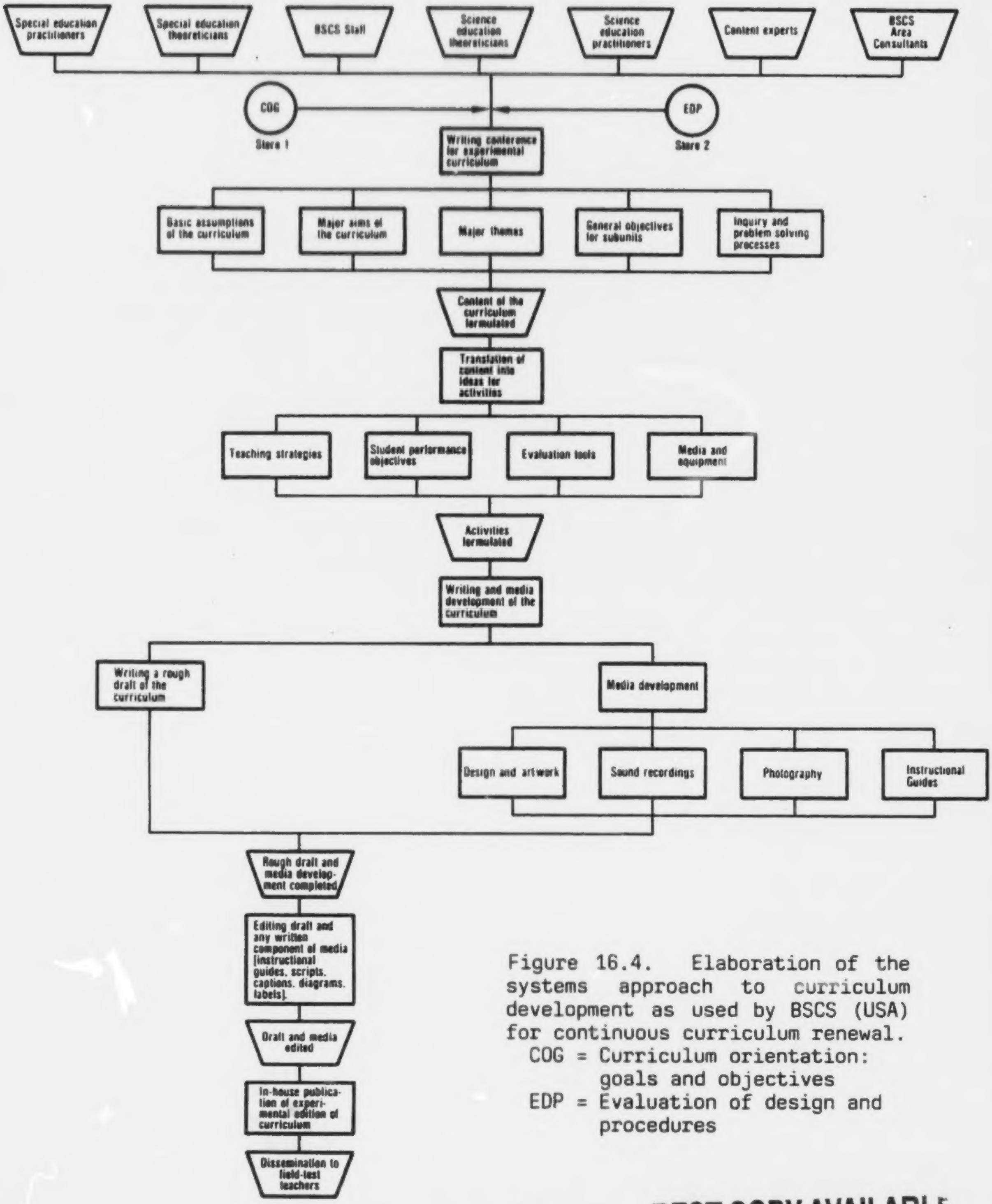
Special education practitioners
Special education theoreticians
BSCS Staff
Science education theoreticians
Science education practitioners
Content experts
BSCS Area Consultants
COG
Store 1
EDP
Store 2
Writing conference for experimental curriculum
Basic assumptions of the curriculum
Major aims of the curriculum
Major themes
General objectives for subunits
Inquiry and problem solving processes
Content of the curriculum formulated
Translation of content into ideas for activities
Teaching strategies
Student performance objectives
Evaluation tools
Media and equipment
Activities formulated
Writing and media development of the curriculum
Writing a rough draft of the curriculum
Media development
Design and artwork
Sound recordings
Photography
Instructional Guides
Rough draft and media development completed
Editing draft and any written component of media [instructional guides, scripts, captions, diagrams, labels].
Draft and media edited
In-house publication of experimental edition of curriculum
Dissemination to field-test teachers

Figure 16.4. Elaboration of the systems approach to curriculum development as used by BSCS (USA) for continuous curriculum renewal.
COG = Curriculum orientation: goals and objectives
EDP = Evaluation of design and procedures

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The detailed BSCS model is reproduced here (Figure 16.4) to indicate the importance of team involvement, meticulous step-by-step planning, the importance of evaluative feedback (eg. COG and EDP) and the obvious need for scrupulously scheduled implementation.

The remainder of this chapter follows the more general steps of the Meyer model (Figure 16.3). Brief comments are provided on those aspects of each step relevant to the development of a programme of secondary school biology which stresses "science for action" and "science for citizens" (Figure 16.1).

16.2 Determining Needs

In education the term "need" may be thought of in three ways. Firstly there is the deficiency approach which defines a need in terms of a "gap" between present and optimally desired outcomes, situations or products. Secondly need may be expressed in terms of competencies, that is by the duties and tasks involved in undertaking some job. Thirdly needs may be expressed in relation to gaps in a hierarchy of knowledge needed for some purpose (8). All these types of "need" are relevant to school biology but are rather differently expressed according to whether the main focus of the programme is on "pure science", "science for action" or "science for citizens". The following table (Table 16.1) gives some examples of statements of need appropriate for the three types of programme.

Table 16.1. Examples of Educational Needs in Three Types of School Biology Programmes

Pure Science	Science for Action	Science for Citizens
. Students should have a clear knowledge and understanding of the main concepts of biology.	. The utilization of basic biological ideas and processes in new areas such as biotechnology should be known and understood by students.	. All citizens should be biologically literate.
. Students should appreciate the processes and methods of biology as a science.	. The application of biological techniques in developing new commercial products should be known and understood.	. Biology should be appreciated as a powerful agency for national development.
. Students should become competent in technical skills such as ecological field techniques, dissection, use of	. Students should	. Biological aspects of social issues such as family planning; health education and conservation of the environment should be understood and appreciated by all

Pure Science	Science for Action	Science for Citizens
the microscope and experimental methods.	appreciate the role of biology in applied areas such as agriculture, medicine and forestry.	citizens.
. Students should read widely about biological discoveries and about new ideas in biology.	. Careers with a basis in biology should be fostered by examining the role and application of biological ideas and processes in appropriate examples.	. All citizens should be able to solve social problems with a basis in biology, objectively and rationally based on an understanding of the science involved.
... And so on	... And so on	... And so on

As has been shown in this volume the world trend has been away from the types of needs expressed in column 1 towards those expressed in column 3. Some science and society movements have tended to concentrate to some extent on the types of needs expressed in column 2, but this approach demands considerable scientific rigour and is not suitable for all types of students, nor is it feasible for all school systems.

Clearly the needs as outlined above cater for three types of students. The first group (column 1) caters only for those wishing to pursue further studies in biology perhaps with the aim of becoming research biologists. The statements in the second column are more likely to cater for students aiming to enter applied jobs or professions such as farming, medicine or laboratory work of some kind. The types of needs set out in column three are general educational needs suitable for all citizens.

Curriculum planners must be clear about the types of people for whom the course is for and about its purpose. It could well be that the programme should cater for a "mix" of needs across all three levels shown in Table 16.1. If that is the case, however, the proportions, or weightings, given to each category should be carefully determined and reflected in the subsequent design.

16.3 Defining Course Objectives

Objectives of a course are derived from the needs. Modern practice suggests that statements of objectives should be expressed in overt behavioural language using "action" words such as make, list, define, calculate and so on. It is beyond the scope of this volume to review techniques for writing statements of objectives and readers are referred to the general literature (9). It is important, however, to stress that course objectives should cover the three psychological domains - cognitive, affective and psychomotor (see Chapters 9-12).

Since objectives are derived from needs they will be rather different for the three types of school biology programmes (i) pure science (ii) science for action and (iii) science for citizens (Figure 16.1). Examples of the types of objectives are given in the following table (Table 16.2).

Table 16.2. Examples of Statements of Educational Objectives for Three Types of School Biology Programmes

At the conclusion of the course you should be able to:

for "pure" science:	for "action" science:	for "citizen" science:
. describe the evidence for organic evolution	. discuss applications of cell biology in the processes of biotechnology	. discuss the role of biology in improving the quality of life of all citizens
. define photosynthesis	. undertake experiments to investigate the relative fertility of soil on different farms	. apply a knowledge of ecological principles for preparing cases for and against development projects which would degrade the natural environment
. solve problems of inheritance by applying Mendel's Laws	. define biological fermentation and describe its applications in the chemical industry	. critically evaluate arguments for and against performing experiments on human embryos
. make clear observations of micro-organisms and tissues using low and high powers of the microscope	. evaluate the use of growth and sex hormones in small animal farming eg. chickens, rabbits	. demonstrate willingness to be involved in community action
. make a general dissection of a small mammal such as the rabbit		

At the conclusion of the course you should be able to:		
for "pure" science:	for "action" science:	for "citizen" science:
. demonstrate willingness to take part in field excursions ... And so on	or pig farming . demonstrate willingness to undertake a programme of work experience in a biology-based industry ... And so on	opposing an unpopular commercial development which reduces environmental sustainability . prepare proposals for government consideration on biological aspects of national development ... And so on

Most biology programmes will contain a "mix" of these three types of objectives, but the mix should of course reflect the predetermined weightings assigned to the three categories of need (Table 16.1). Also the weightings across the three psychological domains should vary somewhat. For "pure" science it is perhaps the cognitive domain which should dominate; for the "applied" type programme both cognitive and psychomotor objectives should be emphasised while in the "science for citizens" type programme the affective domain is critically important. All three domains, however, should be adequately represented in all three types of programme.

16.4 Selection and Organization of Content

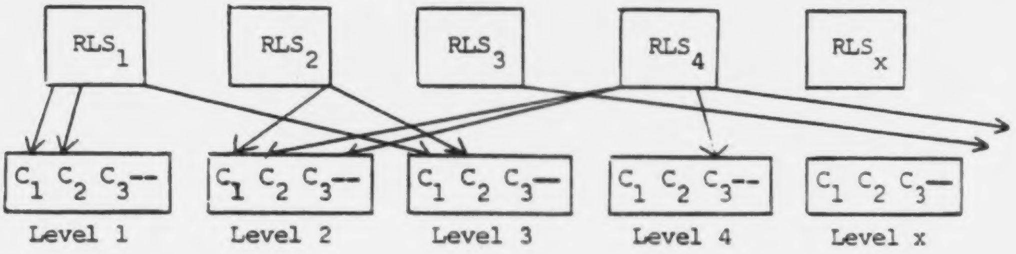
As outlined by Professor M. Subbarini in Chapter 8 criteria for selection of content for modern courses of school biology include social relevance, a focus on social issues and a future orientation. As early as 1974 various biology educators were advocating this type of approach. In 1974 Colin Stoneman commented that the approach taken by the Ordinary Level GCE syllabus for England and Wales was seen by many people to be "out-of-date in a world acutely aware of biological problems" (10). He provided a table (reproduced here as Table 16.3) showing the types of problems which should be dealt with beside the main headings of the Ordinary-Level GCE syllabus of the day (11).

Table 16.3. Selected topics from the 1974 Biology Syllabus for the UK Ordinary-Level GCE and related socially relevant issues (After Colin Stoneman)

Biology syllabus: main subdivisions	Related, current problems commonly discussed but not encouraged by syllabus or examination questions
Food	Famine and world health
Nutrition	
Transport	Drug addiction
Food reserve and utilisation	
Growth	
Control and coordination	Learning, conditioning, brainwashing
Response to environment	Ecology, Conservation, Pollution
Reproduction	Population control
Asexual	
Sexual	Test-tube babies
Dispersal	
Heredity variation	Race
Chromosomes	Genetic engineering
Mendel's experiments	
Evolution	

At a 1981 Sub-Regional Workshop sponsored by Unesco's Asian Programme of Educational Innovation for Development (APEID) these more socially relevant issues were termed "real-life situations" (RLSs) (12). The workshop suggested that RLSs could be selected from a relevant list and organized in one of two ways. These methods are outlined below.

Method A. Link the RLSs to already existing curriculum content as shown in the following diagram (13).



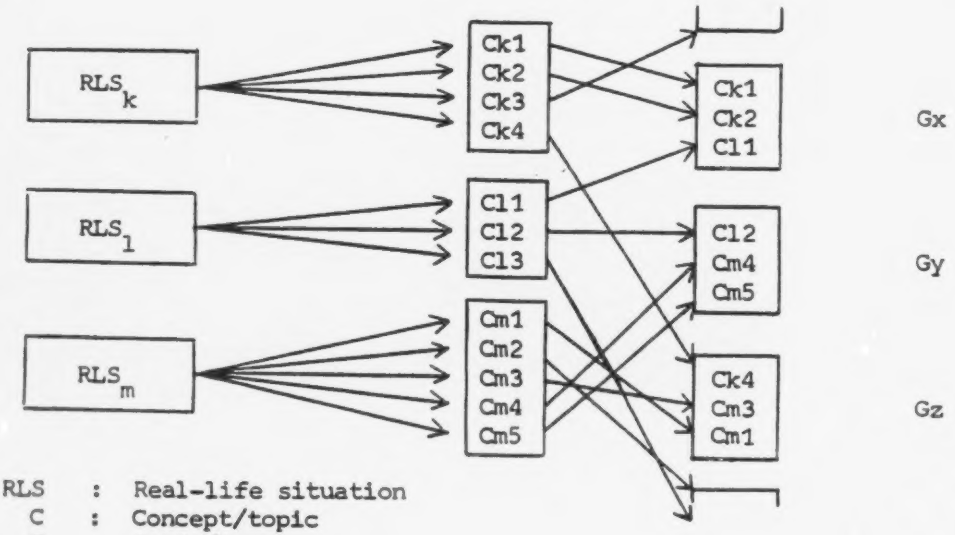
RLS : Real-life situation
C : Concept/topic in existing curricula

The workshop participants commented on Model A as follows:

> "It can be seen from the diagram that certain real-life situations may not be linked with a certain lower level of curriculum but can be linked to a higher level. And also some of the concepts in the existing curriculum may not find a link with any real-life situation, and vice-versa.
>
> If a certain important real-life situation does not link with any level then it warrants a redesigning of the content to accommodate the situation; for science, if it is to be relevant, must take into account an environmental situation that affects the life of a society."

Clearly Method A is suitable for a pure science approach and perhaps for a course emphasising "science for action" but is less appropriate for a programme structured to emphasize "science for citizens" (Table 16.1).

> Method B. "Develop a fresh new curriculum entirely based on the real-life situations and development of productive skills. The identified real-life situations can be analysed for the potential science concepts needed to be acquired for understanding and adjusting with or grappling with each real-life situation. Groups of concepts can then be selected to form the content at each level. The figure below is a diagrammatic representation of the process:" (15)



RLS : Real-life situation
C : Concept/topic
G : Grade/level

The workshop participants commented on Method B as follows:

> "It can be seen that all the concepts at a certain level spring from different life situations. The whole content would be based on real-life situations. This is not achieved in the first strategy where many of the concepts at a particular level in the existing curriculum may not link to any real-life situation.
>
> In the organization of the content selected through this second strategy, any of the available models can be used. The content at any particular level could form a grouping of concepts, topics, units, themes or modules." (16)

Clearly if socially relevant biology rather than "pure science" type biology is to be implemented then Method B is to be preferred since Method A continues to preserve the classical structure of biology as a discipline.

16.5 Selection of Learning Strategies and Activities

The 1981 Unesco APEID Sub-Regional Workshop Linking Science Education to Life mentioned above in Section 16.4 proposed the following criteria for selecting learning strategies and activities for a real-life based science programme (17).

(a) the classroom teaching should be more and more activity-oriented;

(b) environmental situations should invariably be employed in the development of concepts;

(c) the problem-solving approach should be used more often;

(d) locally available resources, both natural and human, should be exploited to the maximum in the daily teaching;

(e) greater amounts of time will need to be given to field trips, excursions and environmental projects;

(f) in all the activities, the learning of processes should be emphasised and acquiring of productive skills should be encouraged at every opportunity; and

(g) in changing to the new styles of teaching, the classroom territory should expand over the whole environment.

In addition it has been suggested elsewhere in this volume that the type of learning activities for socially oriented or "issues" focused biology should not be limited only to the methods of pure science but should also include methods previously considered to be the province of the social sciences (18).

The present author has proposed that learning activities be sequenced according to the INPUT - PROCESS - OUTPUT (IPO) steps of the systems model (19). This scheme is illustrated in Figure 16.5 below.

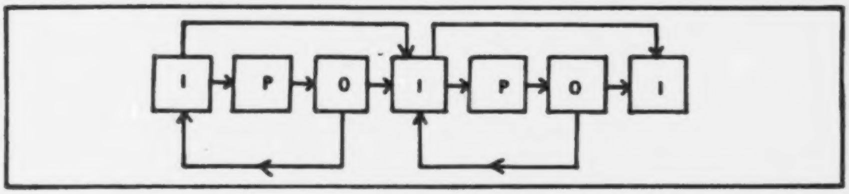


Figure 16.5. Sequencing of learning activities according to the systems approach (After Meyer 1979).

I = Input
P = Process
O = Output

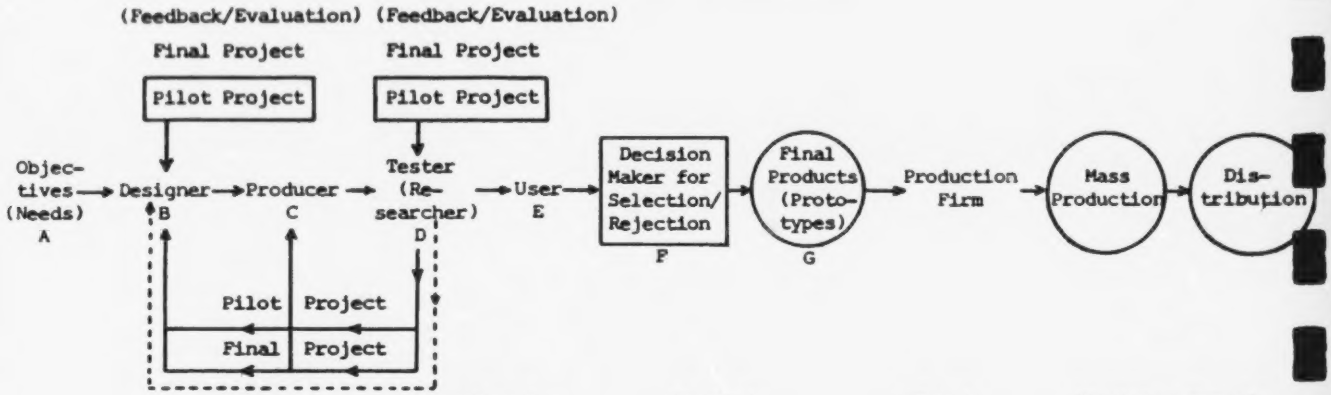
This design is discussed in more detail in the next chapter (Chapter 17). It is sufficient to emphasise here that the approach encourages variety and feedback in learning, promotes participatory learning and provides a structural framework for the integration of science and social-science type learning activities. The table on the following page (Table 16.4), originally developed for a modular approach to curriculum, lists some of the learning activities which could be sequenced in IPO chains (20).

Table 16.4. Selected learning activities appropriate for socially oriented biology classified according to the Input - Process - Output Model (After Meyer 1988)

Input	Process	Output
Study of materials sent before receiving the module precise printed notes short audio programs simple pre-assignments Short reading materials orienting expository problem-solving motivational Printed visual layouts of resources of techniques flow charts Programmed materials (short sequences only) programmed instruction audio-tutorial Keller units Observation of media super 8mm movie slides slide/tape video/tape specimens apparatus machinery equipment models computer programmes Excursions and visits guided observation schedules for visits to to various sites Simulation methods case study descriptions "in-basket" methods simulation games flowcharts computer simulations Group work discussion describing case studies	Individual analysis of input materials listing labelling ranking rating measuring answering questions answering questionnaires filling in proformas responding to checklists reflecting reading reviewing resources calculating interpreting a blue print responding to computer commands Creative responding individual brain-storming self-assessment schedules drawing diagrams problem solving force field analysis group discussion Workshops observational — use of observational schedules, collection of data analytical — examining concepts, equipment resources experimenting-data generating synthetic — building ideas, making resources making equipment, designing tests, writing essays or personal statements evaluative — making choices, checking against criteria	Production of objects/materials media models equipment, apparatus and other objects resources essays poems fine art computer programmes Reporting report writing letter writing preparing audio/video recordings discussions Preparing displays diagrams photographic materials flow charts art work computer displays Planning development of action plans preparation of specifications drawing plans designing simulations computer software Evaluative activities completion of checklists construction of checklists answering tests designing tests preparation of observational schedules product evaluation process evaluation

16.6 Design and Development of Learning Resources

The general principles of resource development have been discussed in Part IV. Details of design are discussed in greater depth in Chapter 17. At this point information is presented on general models for the development and dissemination of learning resources for a specified curriculum. In particular the importance of the production of low cost learning materials is emphasised. A useful general model for the production of such resources has been proposed by a 1977 Unesco APEID Regional Workshop on the Design, Development and Evaluation of Low-Cost Educational Materials (21). This model is reproduced below as Figure 16.6.


(Feedback/Evaluation)
Final Project
Pilot Project
(Feedback/Evaluation)
Final Project
Pilot Project
Objec-tives (Needs) A
Designer B
Producer C
Tester (Re-searcher) D
User E
Decision Maker for Selection/ Rejection F
Final Products (Proto-types) G
Production Firm
Mass Production
Dis-tribution
Pilot Project
Final Project

	(Designer)	(Producer)	(Tester)	(User)	(Decision Maker)
People involved	School Teachers	School Teachers	School Teachers	School Teachers Pupils	School Principals
	Teacher Educators	Teacher Educators Trainees	Teacher Educators Trainees	Teacher Educators Trainees	Teacher Educators
	Ministry of Education Personnel	Ministry of Education Personnel	Ministry of Education Personnel	Teachers Pupils	Ministry of Education Personnel

Figure 16.6. A model for the development of low cost learning materials (After Unesco APEID 1978)

The emphasis in the model on the idea of pilot editions, field trialling and testing and the development of prototypes is especially important for innovative curricula such as a programme of socially oriented biology. Since so many of the ideas are experimental it is important to build-in a process which provides for rapid and flexible modification as aspects are found to need major change or even just fine tuning.

Another point already emphasised (Part IV) is that it is probably the low cost locally produced learning resource which will prove most useful for socially oriented biology. This is because of the need to focus on, respond to and produce resources for the study of local issues.

16.7 Providing for Assessment of Outcomes

Assessment has been discussed at some length in Part III. The Unesco APEID report on Linking Science Education to Life referred to in Sections 16.4 and 16.5 makes the following comments on the evaluation of outcomes for a science course which focuses on real-life situations (22). The views expressed are directly applicable for a curriculum of socially oriented biology.

> "Most of the participating member countries feel that new evaluation techniques and examination systems should be developed with are compatible with new science programmes, especially for linking them to real-life situations or problems. It is also felt that the demands imposed by the existing evaluation methods and entrance examinations will have the effect of degenerating the goals of new real-life linked science curricula into knowledge-bound programmes. It is, therefore, essential that evaluation techniques and examination systems compatible with the objectives of the new programmes be developed.
>
> Evaluation should be based on assessment of student performances in science learning including attitudinal changes, acquiring of productive skills, and creative thinking with respect to real-life situations. Evaluation can also employ various techniques for this purpose including interviews with students.
>
> Furthermore, useful school experiences of students and their school records should be considered essential to complement the results of the entrance examination." (23)

In relation to curriculum development it is important to again stress the need to build in learning activities for the purpose of assessing the achievement of objectives. Some of these should be for grading and some not for grading. They should be located at nodal points of the curriculum sequence.

The broadening of assessment methods advocated in the Unesco APEID report quoted above is especially significant for biology courses based on a societal theme. This allows for all relevant categories and levels of cognitive, affective and psychomotor outcomes to be assessed.

16.8 Curriculum Evaluation - Design Feedback

The final stage (Step 6) of the systems model of curriculum development presented in Figure 16.3 is concerned with checking whether or not all aspects of the programme are appropriate and effective. This process is both formative and summative. That is it should proceed (i) during the initial development and trialling of all aspects and (ii) throughout the implementation period of the curriculum. Formative evaluation should be responsive to continuous feedback from all phases of the design and developmental process. Summative evaluation should be responsive to changes in the context of the curriculum - particularly to changes in need - and so should provide guidelines for up-dating the programme to ensure continued relevance to changing societal circumstances.

The following table (Table 16.5) contrasts a "pure" science and a "socially oriented" biology curriculum in regard to the qualities to be emphasised in evaluating the appropriateness and effectiveness of the two approaches.

Table 16.5. Evaluation Emphasis in two types of School Biology Curricula

Stage of Curriculum Development	Pure Science Approach	Socially Relevant Approach
Analysis of Need	Does the course adequately cover the structure and processes of the discipline at a level appropriate for the intended learners?	Does the course meet the day-to-day living needs of the intended students and the short and long term needs of society as a whole?
Objectives	Will achievement of the course objectives prepare students for further studies in biology?	Will achievement of the course objectives enable students to think critically and solve social problems which have some basis in biology?
Selection of Content	Does the content include all major ideas and concepts needed for further study in the discipline?	Does the content deal with those biologically based problems and issues of concern to the students and to society as a whole?
Organization of Content	Is the content arranged and sequenced in learning hierarchies reflecting the organization of biological concepts?	Is the content arranged and sequenced around a series of real-life situations of interest to the students?

Stage of Curriculum Development	Pure Science Approach	Socially Relevant Approach
Teaching Methods	Do the teaching methods reflect the processes of biology and the inquiry approach to the learning of science?	Do the teaching methods reflect (i) the processes of biology (ii) the inquiry approach and (iii) techniques for analysing social issues?
Assessment of Outcomes	Does assessment focus on the achievement of objectives which prepare students for further studies in biology?	Does assessment focus on the achievement of objectives which prepare students for life?

Clearly the qualities emphasised in curriculum evaluation depend on the purpose of the curriculum. If the purpose is to contribute to an improved quality of life for all citizens and to overall societal wellbeing then it is societal applications which must be emphasised rather than the characteristics of biology as a scientific discipline.

16.9 Conclusion

Since the world trend revealed by the survey reported in this volume is towards teaching biology for social relevance, approaches to curriculum design and development which merely reflect the structure and concerns of biology as a pure science are no longer valid. An important aspect of design is the need for flexibility so that programmes can cater for locally relevant needs and for changing societal circumstances.

Another important feature of many contemporary programmes is the provision of alternatives for different types of need and for different categories of learners. It should also be remembered that for a small group formal approaches to biology remain valid and that in some way provision should be made for this.

In conclusion, however, curriculum developers should now appreciate that for the vast majority of students the purpose of school biology is to help in personal development and to contribute to positive growth and improvement of society as a whole.

Notes and References

(1) Lewis, John L. "Science in Society" in Unesco: New Trends in Integrated Science Vol V. Paris: Unesco 1979 pp 153-160

(2) Figure 16.2 and discussion modified from Mayer, William V. "The BSCS Process of Curriculum Development" BSCS Newsletter No 64 September 1976 pp 4-10

(3) Tyler, Ralph Basic Principles of Curriculum Development. Chicago: University of Chicago Press 1950

(4) Taba, Hilda Curriculum Development Theory and Practice. New York: Harcourt Brace and World 1962 526 pp

(5) Meyer, G. Rex "The Development of Minicourses (with a Basis in Educational Technology) for the Inservice Education of Teachers and Trainers" Programmed Learning and Educational Technology Vol 16 No 1 February 1979 pp 23-37

(6) For an extended discussion of the systems approach to curriculum development see:
Davis, Robert H., Alexander, Lawrence T., and Yelon, Stephen L. Learning Systems Design an Approach to the Improvement of Instruction. New York: McGraw Hill 1974 342 pp

(7) Mayer, William V. Op. Cit. note 2

(8) Meyer, G. Rex Modules from Design to Implementation Second Edition. Manila: Colombo Plan Staff College for Technician Education 1988 pp 62-65

(9) See for example:
Mager, Robert F. Preparing Instructional Objectives. Palo Alto California: Fearon Publishers 1962 60 pp

(10) Stoneman, Colin "The Need for Change" in Selmes, Cyril (Ed) New Movements in the Study and Teaching of Biology. London: Temple Smith 1974 pp 267-287

(11) Ibid. p 272

(12) Unesco APEID Curriculum Development: Linking Science Education to Life Report of a Sub-Regional Workshop on Designing and Developing Innovative Science Curriculum and Instructional Materials Bangkok, 8-20 December 1980. Bangkok: Unesco Regional Office for Education in Asia and the Pacific 1981 74 pp

(13) Ibid. p 50

(14) Ibid.

(15) *Ibid*. p 51

(16) *Ibid*.

(17) *Ibid*. pp 51-52

(18) Meyer, G. Rex *Strategies for Improving the Social Effectiveness of Biological Education at School Level - with Special Reference to Innovative Methods of Teaching* (ISMED Occasional Paper No 4). Quezon City Philippines: Institute for Science and Mathematics Education Development (ISMED) University of the Philippines 1983 18 pp

(19) Meyer, G. Rex *Op. Cit*. note 5

(20) Meyer, G. Rex *Op. Cit*. note 8

(21) Unesco APEID *Design, Development and Evaluation of Low-Cost Educational Materials Report of a Regional Workshop Kuala Lumpur, 5-15 December 1977*. Bangkok: Unesco Regional Office for Education in Asia and Oceania 1978 70 + xxiv pp

(22) Unesco APEID *Op. Cit*. note 12

(23) *Ibid*. p 55

Chapter 17

DESIGN OF LEARNING MATERIAL

17.1 Introduction: The Systems Approach

As in the case of the curriculum as a whole, a systems approach to design of learning materials is probably most appropriate for more recent approaches to biology teaching reviewed in this volume. In Chapter 16 the INPUT-PROCESS-OUTPUT (IPO) model was briefly reviewed at the macro-level of course development. The IPO approach is also appropriate at the micro-level, that is for lesson presentation and for development of learning materials on which lessons are based - see Figure 16.5 (1).

At this level input is information presented to the learner for consideration or action; it is the objectives and content of a sequence of work. A process is some form of interaction between learners and content. It is participatory in nature and will appear as a learning activity such as practice task or some form of interpersonal interaction. Output means a demonstration of achievement by production of something tangible: demonstration of a new skill; completion of achievement quiz; construction of an object; presentation of an oral or written report, and so on.

Materials designed in this way are activity oriented chains of IPO with the output of each leading into the input of the next and with each being strengthened by feedback from the subsequent IPO (Figure 16.5).

The overall educational advantages of this design model are as follows:

- it builds in active participation through the process and output steps
- it provides a ready framework for reinforcement because the IPOs can be considered as Stimulus (I) and Response (PO) sets
- behavioural outcomes are made overt and easy to modify
- since I, P or O can each use highly diverse methods, variety is built in and interest maintained
- learning is broken into small hierarchical steps
- assessment of achievement is built in through the output demonstrations

- consolidation is readily achieved by building in summative or nodal outputs

- it is possible to aggregate IPOs into super IPOs so that some are mainly concerned with input, others with process and others with output (2).

For more socially oriented biology this model is especially useful because it provides a framework for building in approaches suitable for the social as well as the pure sciences.

17.2 Examples of Learning Sequences Using IPO

Materials designed on the IPO model are usually in the form of modular workbooks or study guides (3) but the approach is also appropriate for textbook design.

The following are examples of how a text could present individual IPOs.

Example A: The Pure Science Approach

Topic: *Experimental design - plant transpiration.*

INPUT: *Illustrated text describing the principles of transpiration in a flowering plant.*

PROCESS: *Presentation of alternative methods of measuring rate of water loss from a flowering plant. Instructions for students to form small discussion groups to select the most appropriate method.*

OUTPUT: *Groups defend their choice by comparing against criteria presented in the text. Reports shared with other groups.*

Leading to next IPO →

which would involve setting up (I); performing (P) and evaluating (O) the experiment of their choice.

Example B: An Applied Science Approach

Topic: Causes and effects of soil erosion in farmland

INPUT: Tabular list of causes of soil erosion.

PROCESS: Instructions and observational checklists for visits to well managed and to eroded farms.

OUTPUT: Questions and guidelines for groups to prepare reports on observations and conclusions. Reports shared on (i) causes and (ii) effects of the observed erosion.

Leading to next IPO →

which could involve using the reports from the previous IPO (I) as basis for discussion of possible ways of overcoming problems of the eroded farm (P) and to prepare a suitable plan of action (O).

Example C: A Social Issue Approach

Topic: Survey of physical recreational facilities in the district.

INPUT: Instructions for student discussion groups reviewing and listing sporting and other physical activity facilities near their homes.

PROCESS: Instructions for organizing data from the discussion and for combining data from all groups.

OUTPUT: Guidelines for preparing a list of needs in priority order and for writing a summary of the situation.

Leading to next IPO →

which could involve using the list of needs (I) as a basis for reviewing what action should be taken (P) and the preparation of a proposal for consideration by local authorities (O).

The above examples indicate how IPOs could form the structural basis of any learning resource such as a textbook and also how they can be used as the basis for programming a lesson. There are of course other qualities of textbook design which need to be addressed and some of these are briefly reviewed in section 17.3 below.

17.3 Qualities of Good Textbook Design

The Unesco Handbook for Biology Teachers in Asia has an especially useful chapter on this issue (4). The discussion highlights the need to design a book which (i) focuses on achievement of the curriculum objectives (ii) is at an appropriate level of difficulty (iii) is practicable in terms of time and (iv) caters for assessment requirements.

In addition the Unesco Handbook contains a useful instrument for evaluating a textbook. This could be used formatively during the development of a text or summatively for the selection of an already published book (5). This instrument is reproduced below as Table 17.1.

Table 17.1. Evaluation of a Textbook
(After: Unesco Handbook for Biology Teachers in Asia)

NAME OF SCHOOL . . . .

ABILITY OF STUDENTS . . . .

TEACHER'S QUALIFICATIONS . . . .

TITLE OF TEXTBOOK . . . .

Instructions

(i) Please put a tick (✓) in the cell corresponding to your response.

(ii) Please answer with your students' needs in mind.

(iii) Note that in some aspects, you need to tick under more than one heading.

ASPECTS OF TEXTBOOK	SYLLABUS ← TEXTBOOK ↓	Topic I... Subtopic	(a)	(b)	(c)		Topic II
OBJEC-TIVES	1. Objectives clearly stated 2. Content reflects objectives						
CONTENT	1. Not sufficient 2. Just right 3. More than required						
APPROACH/PRESENTATION	1. Guided discovery approach (lots of questions and suggested activities)						
	2. Expository approach (straight forward stating of facts)						
	3. Language easily understood by students						
	4. Language understood by students only after teacher's guidance						
	5. Language too difficult for students						
	6. There is useful summary at the end of section on activity						
	7. No summary at the end of section or activity/summary not useful						
	8. Concepts involved are above the understanding level of students						
DIAGRAMS/ ILLUSTRA-TIONS/ GRAPHS	1. None - because not needed						
	2. None - although needed						
	3. Clear, comprehensive						
	4. Unclear, misleading						
	5. Not sufficient						
EXPERI-MENTS/ ACTIVITIES	1. Inadequate						
	2. Difficult to carry out						
	3. Cannot be carried out						
	4. Just right						
	5. More than required						
	6. Irrelevant to content						
EXERCISES/ DISCUS-SIONS	1. Adequate						
	2. Inadequate						
	3. Not in accordance with content presented - too difficult						
	4. Too simple - only direct questions						
TIME	Approximate length of time required to cover the topic						
EVALUA-TION	1. Adequate						
	2. Inadequate						
	3. Weak test items						
	4. Many objectives not measured						

In addition to these general qualities, textbooks for socially relevant biology should have the following features.

1. Some structure such as an IPO approach which provides a framework for active participation, critical thinking, problem solving and developmental planning.
2. An approach which focuses on social issues and which draws on the content of biology to explicate the issues.
3. A stress on procedures and methods - in particular the provision of guidelines for case study analysis, group activities and for preparing reports and action plans.
4. A stress on real-life issues of concern to the students, the local community and the nation as a whole.
5. An approach which makes outcomes overt and which thus makes it easy to assess the quality of learning.

17.4 Audio-Visual Materials

In this volume it is not possible to describe in any detail aspects of the design and development of each type of audio-visual resource and suitable references are given at the end of this chapter (6). The following table (Table 17.2) provides a few general comments on some of the more widely used educational media. The table gives some general guidelines and some comments of direct relevance to production for socially relevant biology.

Table 17.2. Notes on Selected Audio-Visual Media for Socially Oriented Biology

Medium	General Comment (7)	Development for Socially Relevant Biology
1. Still Photographs	When produced in sets or kits, usually with accompanying notes, these are referred to as study prints. Photographs can, of course, be taken of real people, from books, magazines or newspapers. They can be reproduced relatively cheaply in the text itself but the advantage of producing them as a separate set of study prints is that they can be used by students in a variety of activities involving sequencing,	Study prints of critical situations in the local district are especially recommended eg. (i) logging of native forests (ii) stages in development of a local freeway.

Medium	General Comment (7)	Development for Socially Relevant Biology
	sorting into categories, ranking on certain criteria and so on.	
2. Wall Charts and Posters	Very valuable in group-paced situations. They can be produced relatively cheaply, should be large (say a minimum of 1 metre square) and should not contain too much detailed information. There is a temptation to cram too much detail into many charts and this leads to confusion and dislocation of learning. In some instances it may be appropriate to reproduce the wall chart - or a version of the chart - as an illustration within the textbook or as mimeographed hand-outs.	Teacher and pupil-made charts and posters are useful ways of summarising case study findings or of action plans.
3. Flip-Charts	These are very useful in large group settings to show the build up of an idea step-by-step such as steps say in performing an experiment. They can actually be reproduced in the textbook or issued on mimeographed sheets in the form of a strip cartoon or a series of drawings laid out in sequence.	Useful for showing procedural steps in situations involving (i) a social survey (ii) interview techniques or (iii) procedures for a simulation game or other form of simulation.
4. Board Display	These are also primarily intended for group work and like flip-charts have the advantage of showing the step-by-step build up of an idea. They have the additional advantage in that smaller elements can be added or deleted to highlight special features. Versions of board displays can also be reproduced as illustrations in the text-	As for flip-charts. Also useful for building up conceptual schemes and especially suitable for action plans.

Medium	General Comment (7)	Development for Socially Relevant Biology
	book - either as a step-by-step sequence or as a finished product. Chalk boards; peg boards; magnetic boards and felt boards are all useful.	
5. Graphics (Drawings)	Drawings, diagrams and other forms of graphic illustrations do not have to be of top quality artistically to be educationally effective. Cartoons are especially useful in making a point and these can be based on famous cartoon characters from the mass media or be much more simply developed by using "matchstick" figures and so on. Graphics help a great deal to make a text visually appealing and educationally interesting. Use of templates, stencils and adhesive lettering facilitates production.	All aspects of biology are highly visual and so graphic representation is an important aspect of teaching. In a socially relevant programme this can take the form of illustrating visits to study sites such as farms, factories, housing estates and so on.
6. 35mm Slides	Coloured photographs are expensive to reproduce in the pages of a book. If colour is needed to illustrate coding (eg. electrical wiring) or to add dramatic effect or realism, then colour slides are good substitutes. Sets of slides can be viewed through hand viewers by students working through a lesson at their own pace or they can be projected in the usual way in a group-paced situation. Production is relatively straight forward provided a 35mm camera or an instamatic camera is available. Production of slides is facilitated if a Kodak Instamatic Visual Maker can	Slide sets made cooperatively by teachers and students are valuable in providing data or for reporting findings from the study of local situations eg. degradation of a local forest by wood cutting for fuel. They are excellent for illustrating a school report to the local community.

Medium	General Comment (7)	Development for Socially Relevant Biology
	be obtained. This device provides a fixed focus and a standard form of lighting which greatly simplifies production. Slides, of course, must be carefully planned and sequenced using a story board technique. Slide/tape sets can be produced with the aid of a slide tape synchronizer. Alternatively a cassette recording can be used in conjunction with the slides with audible signals to alert students when to advance the slides.	
7. Strip Films	Strip films are easier to package and distribute than slide sets but lack the flexibility of slides which can be re-arranged in any appropriate sequence. Strip films are especially useful to show steps in a practical task since it is easier to move from frame to frame than from slide to slide. Production is similar to slide sets and can involve a suitable mixture of original photographs, diagrams and printed text. The frames of a strip film can, if necessary, be reproduced in the text in black and white. Sound can be added by synchronisation with a cassette recording - an audible signal can be added to instruct students when to move on.	Helpful in setting out steps in a procedure - especially for a visit to a site outside the school such as a local retail complex.
8. Overhead Trans-parencies	While overhead trans-parencies are mainly used in group situations they also have a place in self-	Helpful in step-by-step building of conceptual schemes eg. origin of values held by various

Medium	General Comment (7)	Development for Socially Relevant Biology
	paced instruction. Individual students can interact with transparencies if they are creatively designed to include overlays or animation techniques. Transparencies can illustrate step-by-step build up, show how parts interact and even illustrate the movement of components. Production is relatively straight forward provided a good range of graphic art facilities is available. Versions of all overhead transparencies should be reproduced as illustration in any text.	community groups.
9. Movie Film	35mm and 16mm movies are expensive to produce but if a really good movie is commercially available which illustrates a point that cannot be easily made in any other way then it should be used. 8mm and super 8mm movies are on the other hand quite inexpensive to produce. They are especially effective to illustrate a single concept or a set of procedures. They can be used in self-paced systems by students who can project them on to small daylight screens using either open reel or cartridge formats. Production techniques are relatively simple provided an appropriate movie camera is available and the story board technique is applied. Sound can be added by synchronisation with a cassette recording.	Frequently useful movie films are produced by government agencies to promote socially relevant programmes. 8mm movies can be produced by students to record steps in their investigation of a local issue.

Medium	General Comment (7)	Development for Socially Relevant Biology
10. Audio Programmes	In almost all educational systems open reel tape systems have been replaced by cassettes not only because of lower cost but also because of greater convenience in packaging and distribution. This medium is generally underutilized in science programmes and yet production is relatively simple as most low cost cassette systems have in-built microphones. Audio programmes can greatly enhance reality, provide instructions for on-site practical work, especially in noisy working environments where earphones can dampen irrelevant sounds, and they also make messages seem very much more personal and direct. They can compensate, too, for poor reading skills. Nevertheless, the script of any audio programme should be printed in the text form. Audio taped programmes are reasonably easy to produce provided the sequence is followed for generating a spontaneous recording, transcribing the recording as a pre-script and only then producing a final script. Audio programmes should sound as natural and spontaneous as possible and not appear as though read from a formally written production script.	Especially useful for recording interviews. Also helpful to provide commentary for visits to factories, botanical gardens and for nature trails. Students should be involved in production.
11. Objects	Real objects, models and simulations all have a key role in science instruction, especially in the organisation of practical	Real objects (specimens, science equipment etc.) are the mainstay of any programme of school biology. In socially

Medium	General Comment (7)	Development for Socially Relevant Biology
	work. Instructions on how to observe or manipulate the objects must be carefully set out. In the case of real objects it is sometimes advisable to cover, screen or mask irrelevant parts - if, of course, it is practicable to do so. Colour coding of parts is also helpful at times. Models should highlight only those aspects of the real objects they represent, not all the unimportant or irrelevant details need be included. Models have the advantage, too, of providing cut-aways, cross sections and easily disassembled components. Simulations can include games for one or more players either in the form of board games such as well known real-estate games or card and dice games. The main production factor to consider is ease of mass production of the model or simulation and the general availability of a real object.	relevant programmes this use extends to the whole natural and artificial environment. All the objects in the local environment become potential teaching resources.
12. Video Programmes	Cassette video tapes are now readily available and programmes are relatively inexpensive to produce and mass produce. They require production techniques not too dissimilar from 8mm and super 8mm movies but, of course, require quite different technical facilities. Video has the advantage of flexible editing as compared with movie film and the modern video camera is relatively easy to use. Quite competent	As for 8mm and super 8mm movies.

Medium	General Comment (7)	Development for Socially Relevant Biology
	programmes can be made by relatively inexperienced producers provided single concepts or carefully sequenced steps are involved and provided the story board technique is applied. There is no point, however, in using video recordings unless all users can be guaranteed ready and instant access to compatible video tape players and monitors.	
13. Computer Programmes	The advent of relatively inexpensive micro-computer systems has made the use of computer-based programmes much more realistic than in past years. There is now available an excellent range of commercially produced computer programmes. The development of especially designed programmes is also a possibility provided designers are trained programmers or have access to trained programmers. Computer based programmes have the special advantage of being highly interactive, fully self-paced and capable of illustrating quite complex simulations. They are, therefore, especially suitable for science instruction provided they can be adequately programmed and made readily available to all users.	Especially useful for presenting and analysing social simulations.

The emphasis in Table 17.2 is on the production of audio-visual resources by teachers and students. In socially oriented biology this is especially important since the materials must relate to local situations.

17.5 Provision for Alternatives

Throughout this volume the need for flexibility in the design of the overall curriculum and in design and production of learning materials has been stressed. A further aspect of the issue of flexibility is the need to provide alternatives.

In the first place alternative methods and materials are needed to cater for the individual differences of students. This may be achieved within group-paced learning or through some form or forms of individualized instruction such as programmed learning, contract learning or audio-tutorials. In the second place alternative approaches may be required in the selection of case studies or social situations due to local factors such as numbers, safety, willingness of local groups to participate and so on.

Because socially oriented biology emphasises aspects of personal development and meeting personal and community needs self-paced and individualized approaches would be especially appropriate (8).

In regard to self-pacing and independent learning there may be situations where an entire course may involve these approaches but usually self-paced segments are built into conventional group-paced courses. The following notes provide some guidelines on various types of self-paced systems (9).

> Individual reading. Individuals may be assigned extended reading programmes over several weeks or, alternatively, short reading sessions can be "built-in" to a given lesson. In the latter case the reading should be short, written in a clear and direct style and preferably be broken up into distinct steps or points.
>
> Programmed reading. Sometimes it is appropriate to arrange for reading to be broken into distinct learning units each with clearly stated objectives and "in-text" questions for the learner to check on progress.
>
> Linear programmed instruction. In a linear programme, information is broken into small steps or frames. Individuals work through the material at their own pace. They respond to each frame by answering a simple question which is "corrected" in the next frame. These questions are "fail-safe" and learners gain satisfaction from getting answers right. This is reinforcement. The reinforcement and continual feedback characteristic of linear programmes helps to ensure that learning will take place.
>
> Branched programmed instruction. In many respects similar to linear programmes, branched programmes consist of frames and response questions. They provide reinforcement and give feedback. They differ from linear programmes in having multiple choice questions at the end of each frame and having more "information" in each frame. If answers

are correct, the learner moves to the next frame in the main sequence. If answers are incorrect, the learner is directed to a remedial frame or frames which correct the mistake and give the relevant information again in a more direct manner. Like linear programmes, branched programmes can be presented in book form (known in this case as "scrambled" books) or by means of teaching machines.

Computer assisted instruction. Branched and linear programmes can be presented by means of a computer linked to a special interactive terminal. In some cases the learner can control the direction of the programme to fit particular needs.

Programmed media. Film strips, slide sets, movie films and other media can be designed for individualized study by treating them in the same way as linear programmes. Questions can be inserted at appropriate points either using the same medium or by having a printed study guide to accompany the non-print media.

Audio-tutorial. Individuals study at a learning booth. Information is presented mainly by means of audio-tape. Other media may be used such as video-programmes, slides, equipment, specimens and other objects. The learner is tutored by the taped-programme and answers questions and undertakes assignments written up in an accompanying study guide.

Modular instruction. Learners work through self-paced self-instructional manuals. They take a mastery test after each module and if they attain a satisfactory standard they then proceed to the next module.

Keller Plan (Personalized System of Instruction or PSI). This is a mastery approach based on substantial blocks of reading involving in-text questions and mastery tests. The tests are administered by fellow-students who have been through the system already - these "examiners" are termed proctors. The text is organized into units of work and each must be mastered before proceeding to the next unit.

Each of these approaches has its own design characters but details are outside the scope of this volume. It is easy to see, however, how the IPO systems approach could provide a framework for introducing specific learning activities based on various types of self-pacing.

In regard to individualized learning the situation is more complex (10). Individualized learning is different from independent or self-paced learning although it may include some self-paced activities. By individualized instruction is meant that the needs of each individual learner are diagnosed, learning pathways are prescribed leading to the achievement of negotiated objectives, and assessment of achievement is undertaken at regular intervals.

Usually the work is organized into modules or units and the programme is frequently based on a mastery approach. The learner and the teacher sometimes sign a contract for the organization and completion of each unit of work.

Individualized learning does not always involve the learner in working alone. A wide range of instructional options is usually available and the learner combines work in large groups and in small groups with self-paced activities according to his or her personal need and according to the nature of the objectives to be achieved. Generally educators recognize three types of individualized approach. These are briefly described below.

> Individually prescribed contracts. Continuous diagnosis is central to this approach and learners enter into appropriate short term and longer term contracts for mastery of all types of experiences and subject matter, some based on modules, some on "open study" methods, some on visits or experiential learning and so on.
>
> Individually Prescribed Instruction (IPI). The needs of each individual are carefully diagnosed by means of observations, tests, task analysis, etc. and an appropriate educational programme is prescribed over an agreed period of time. Very similar to the contract approach but not so strictly based on a mastery model.
>
> Cognitive style mapping and individual prescription. A combination of the contract and IPI approaches based on a detailed analysis of cognitive style. Weekly work units are prescribed in a wide range of learning centres involving contrasted methods of teaching. Each week's work must be mastered before a learner proceeds.

Both self-paced and fully individualized approaches have design and management implications for curriculum and learning materials. Individualized instruction is rarely totally implemented because of high costs and administrative difficulties. In systems which do utilize this approach, record keeping is usually monitored by a computer. In the United States, Oakland College, Detroit, has a computer programme to compile a "cognitive map" for each student and to prescribe a weekly sequence of learning activities from a wide range of instructional options.

While few school systems can totally individualize, it is important to cater to individual differences as far as possible. One compromise is to organize certain units of a total course on an individualized contract basis while using more conventional methods for the majority of the programme.

The more a programme can be individualized, however, the more likely it will be effective in developing skills transferable to every-day living. If an individual with personality patterns somewhat different from the norm can be given self-confidence and shown how to succeed at school this will encourage a positive attitude towards lifelong learning and will lead to successful adjustment to the changing pressures of society (11).

17.6 Conclusion

Socially oriented biology requires a wide range of learning materials catering for three conceptual levels (i) pure science (ii) applied science and (iii) social issue analysis. It is unlikely at present that many commercially produced textbooks cater for all three aspects and many of the learning materials should be produced by teachers and pupils in cooperative teams. The community should also be involved in the design and production of relevant materials. The focus should always be on local needs and local situations.

Also because of its focus on individuality, socially relevant biology should build-in opportunities for self-paced learning wherever possible. In situations where they are practicable, fully individualized systems should be investigated, and as a minimum some aspects of all socially relevant biology should include segments of individualized instruction.

A systems approach to the design of all types of learning material provides a useful framework for ensuring maximum involvement of the learners. It also furnishes a flexible schema to cater for the needs of individuals and for response to varying local circumstances and needs.

Notes and References

(1) Meyer, G. Rex "The Development of Minicourses (with a Basis in Educational Technology) for the In-Service Education of Teachers and Trainers" Programmed Learning and Educational Technology Vol 16 No 1 February 1979 pp 23-37

(2) Unesco Proap: Fifth Sub-Regional Workshop for Training of Literacy Personnel Port Moresby, Papua New Guinea, 3-15 December 1990 Draft Final Report. Bangkok: Unesco Principal Regional Office for Asia and the Pacific 1990 p 68

(3) Meyer, G. Rex Modules from Design to Implementation Second Edition. Manila: Colombo Plan Staff College for Technician Education 1988 385 pp

(4) Unesco: Unesco Handbook for Biology Teachers in Asia. Paris: Unesco 1986 pp 576-587

(5) Ibid. p 577

(6) See especially:
Unesco: New Trends in the Utilization of Educational Technology for Science Education. Paris: The Unesco Press 1974 248 pp
Also see:
Anderson, Ronald H. Selection and Developing Media for Instruction. New York: Van Nostrand Reinhold 1976
Brown, James; Lewis, Richard B.; and Harcleroad, Fred F. AV Instruction Technology Media and Methods Fourth Edition. New York: McGraw Hill 1973

(7) Based on Meyer, G. Rex Op. Cit. note 3 pp 244-246

(8) See for example:
Dale, Edgar Building a Learning Environment. Bloomington Indiana: Phi Delta Kappa 1972 132 pp
Duane, James E. (Ed) Individualized Instruction - Programs and Materials. Englewood Cliffs, New Jersey 1973 368+ 48 pp
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(9) Based on Meyer, G. Rex Strategies for Improving the Social Effectiveness of Biological Education at School Level - with Special Reference to Innovative Methods of Teaching (Occasional Paper No 4). Quezon City Philippines: Institute for Science and Mathematics Education Development (ISMED), University of the Philippines 1983 pp 14-15

(10) Ibid. p 17

(11) Ibid. pp 17-18

Chapter 18

TEACHER DEVELOPMENT

18.1 Attributes and Competencies of Teachers

The newly emerging roles and responsibilities for biology teachers are complex and demanding. Not only must teachers be competent in basic scientific processes and in the acknowledged skills of general pedagogy, but they must also face up to the traditional demands made by the "out-reach" approach linking science to society in general.

Unesco's Handbook for Biology Teachers in Asia (1) has developed an extensive inventory of basic competencies and these are reproduced below as Table 18.1.

Table 18.1. Basic Competencies for Teaching Secondary School Biology (After Unesco Handbook for Biology Teachers in Asia)

I. Equipment and instruments

The secondary school biology teacher should be able to use:

1. alcohol and gas burner
2. balance:
   (a) beam
   (b) platform
   (c) spring
3. barometer
4. burette
5. graduated cylinder
6. distillation unit
7. dissecting instruments
8. incubator
9. manometer
10. compound microscope
11. pipette
12. power supply (AC and DC)
13. thermometer
14. drying oven
15. water bath

II. Laboratory procedures and techniques

The secondary school biology teacher should be able to:

A. prepare
  1. temporary slides
     (a) squash
     (b) smear
  2. solutions
     (a) molar
     (b) percent
     (c) serial dilution
  3. culture media
     (a) sterile liquid
     (b) solid
  4. simple stains

B. use techniques involving
   5. chromatography
      (a) paper
      (b) thin layer
   6. gas collection
   7. handling and storage of chemicals

C. isolate, culture, etc.
   8. algae
   9. bacteria
   10. cells
   11. Drosophila
   12. moulds
   13. protozoa

D. care for live animals in the laboratory
   14. amphibians
   15. birds
   16. small mammals
   17. reptiles

E. set up and maintain
   18. an aquarium
   19. a terrarium

F. do the following
   20. connect and maintain gas cylinders
   21. cut, shape and polish glass rods and tubings
   22. determine number of bacteria present per unit volume of solution
   23. preserve plant and animal specimens
   24. weigh and measure accurately
   25. construct taxonomic keys

III. Emergency procedures

The secondary school biology teacher should be able to:

A. administer first aid for the following:
   1. eye injuries
   2. burns
   3. cuts and wounds
   4. severe bleeding
   5. shock and fainting
   6. animal bites
   7. poisonous chemicals and fumes

B. extinguish fires in the laboratory
   8. by using means according to the type of fire

C. take safety/preventive measures in case of
   9. lightning and electrocutions
   10. earthquake
   11. fire
   12. typhoon/strong winds
   13. flood

D. administer artificial respiration

IV. Mathematical competencies

The secondary school biology teacher should be able to:

A. perform the following skills:
   1. use the following instruments:
      (a) protractor
      (b) drawing compass
      (c) calculator
   2. use scientific notation and significant digits in recording measurements

B. perform the following computational skills
   3. convert from one unit to another
   4. compute with measures recorded in scientific notation with consideration

C. translate from one form to another (words, symbols) statements regarding
   5. percentage

6. ratio and proportion
7. direct and inverse proportions
8. direct square proportion and inverse square proportions
9. probability

D. construct the following:
   10. drawings of 2- or 3-dimensional geometric figures
   11. scale drawings of geometric figures
   12. graph empirical data or of equations

E. perform the following interpretative skills
   13. given a graph (cartesian) of two quantities, establish the relationship
   14. draw inferences from a graph
   15. draw inferences from equations of functional relationships

F. distinguish between

   16. proof and verification
   17. conjectures and logical conclusions
   18. facts and assumptions
   19. inductive and deductive reasoning
   20. necessary and sufficient conditions in a given situation

V. Curriculum projects and professional organizations

The secondary school biology teacher should be:

A. familiar with materials from various curriculum projects of the country and other countries

B. familiar with some journals of Science, Biology Education of the country and other countries

C. familiar with some of the national/regional science organizations

VI. Educational technology

The secondary school biology teacher should be able to:

A. describe and use the following in teaching:
   1. instructional modules
   2. inquiry techniques
   3. investigative laboratory activities
   4. individualized instruction techniques
   5. lessons which reflect the process of science

B. operate a/an
   6. camera
   7. projector
      (a) 35mm slide projector
      (b) overhead projector
      (c) opaque projector
   8. reel sound tape recorder

C. prepare/develop
   9. transparencies

D. utilize library resources
   10. card catalogue
   11. materials in an open-shelf system
   12. vertical files
   13. indices/bibliographies

E. use
   14. techniques of questioning
   15. visual aids appropriate to topics on hand
   16. activity-oriented teaching
   17. instructional games
   18. role playing and simulation

F. construct
   19. improvised equipment
   20. visual aids appropriate to lesson on hand
   21. modules (eg. simple crystals)

G. identify community needs and mobilize, use community resources such as the following in teaching:
   22. government agencies and services
   23. individuals
   24. natural resources
   25. local organizations

H. organize and supervise field trips and field studies

I. plan and equip a laboratory for science instruction

J. identify sources of laboratory equipment and supplies

VII. Educational fundamentals

The secondary school biology teacher should be able to:

A. describe
   1. the nature of science/mathematics
      (a) its relevance to non-scientists
      (b) its relation to other fields of endeavour
      (c) its impact on society
   2. what is meant by scientific/mathematical literacy
   3. his or her personal philosophy concerning
      (a) teaching
      (b) testing and grading
      (c) homework/assignments
      (d) discipline
   4. his or her ethical and legal responsibilities as a teacher
   5. some recent learning theories relevant to science education
   6. students
      (a) what they are like as adolescents
      (b) how they learn
      (c) what their goals are
      (d) how they benefit by studying science
   7. the role of the schools in terms of
      (a) responsibilities to students individually, collectively
      (b) responsibilities to the community local, provincial, national, world

   (c) relationship to other levels and kinds of school
   8. two source books for science teachers
   9. two science/mathematics books for the level I teacher

B. apply techniques for
   10. classroom management
   11. textbook evaluation

C. distinguish between
   12. 'content' teaching and 'process' teaching
   13. facts, concepts and principles
   14. norm-referenced tests and criterion-referenced tests

D. prepare
   15. instructional objectives
   16. a teaching guide plan which reflects objectives
   17. evaluation instruments/activities which reflect stated objectives
   18. an inquiry-oriented instructional activity/lesson
   19. teaching activities that reflect the nature and processes of science and mathematics

E. analyse
   20. objectives using different levels of skills
   21. test items in terms of the following skills
      (a) cognitive (c) psychomotor
      (b) affective

F. apply
   22. a variety of approaches and strategies in making subject matter interesting to students
   23. various forms of motivation to stimulate and sustain student interest in learning
   24. various ways of meeting individual differences for more effective learning
   25. test results and other competency measures in appraising student performance
   26. psychological principles in adapting to making a quick assessment of a classroom situation

G. prepare own materials using science concepts integrated with topics
   27. from other subject areas
   28. from everyday experience
   29. from the local environment

H. utilize both deductive and inductive reasoning

I. do applied research in line with subjects taught as well as on other issues affecting teachers and school

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In addition to competencies listed in Table 18.1 the "outreach" implications of the socially-oriented approach to biology teaching imply that additional tasks need to be performed. These include those listed in the following table (Table 18.2).

Table 18.2. Selected Additional Competencies Required for Socially-Oriented Biology

---

I. Analysing Social Issues

- Case study analysis
- Working with family groups
- Social survey techniques
- Attitudinal and interest survey methods
- Analysing bioethical issues
- Critically reviewing the role of mass media in society
- Analysing government reports

II. Utilizing Pedagogical Skills from the Social Sciences

- Force field analysis
- Team building
- Conflict resolution
- Designing social simulations
- Conducting public meetings
- Interacting with the mass media
- Organizing school-community management committees

III. Fostering the Roles of Individuals in Community Work

- Facilitating personal development of students
- Motivating students for community action
- Organizing work experience for students
- Establishing links between students and the community

IV. Reporting the Results of Studying Social Issues

- Developing action plans
- Preparing proposals for submissions to various authorities
- Displaying data for school and community inspection
- Reporting findings to the general community
- Involving the school in appropriate activist movements (eg. public clean-up campaigns)

The additional competencies listed in Table 18.2 are by no means comprehensive. They are samples of the additional tasks which will become more and more in demand as the movement towards the teaching of socially relevant biology becomes universally accepted.

18.2 Patterns of Pre-Service Teacher Education

Secondary school biology teachers are usually educated in universities or equivalent post-secondary educational institutions. They almost always take separate strands of biological science treated as a pure science discipline and pedagogy, treated as a method of teaching the "pure" science. Sometimes the blocks of science and pedagogy are arranged "end-on" - that is a three year degree in pure biology is followed by one year of pedagogy. Sometimes a concurrent model is followed which while retaining the three to one ratio of content to pedagogy, spreads units of both across a four year programme. A third model sometimes applies as a variant of the concurrent model. This is the "sandwich" approach which alternates larger blocks (at least one semester at a time) of pedagogy and content but which still tends to preserve the three-to-one ratio. In the "end-on", "concurrent" and "sandwich" approaches the biological content is usually presented by discipline oriented biologists and the pedagogy by science educators (2).

An alternative approach which has not been given wide currency is for all aspects of the preparation of biology teachers to be the responsibility of science educators who may, or may not, involve pure scientists for specialized inputs as required. This approach involves a total integration of the science content and the pedagogy. This approach, when it is offered at all, is usually provided by Institutes of Education within universities and is frequently limited to preparing teachers for primary school science and for the lower grades of the secondary school. Preparation for senior secondary school biology almost always follows the more conventional "end-on", "concurrent" and "sandwich" models.

From the point of view of socially-oriented secondary school biology each of the four models has strengths and weaknesses in regard to developing the competencies required. These are summarised in Table 18.3 below. In each case a four year programme of full-time preparation is assumed.

Table 18.3. Strengths and Weaknesses of Four Models of Teacher Preparation for Developing the Competencies Required for Socially-Oriented Biology in Secondary Schools

Model	Strengths	Weaknesses
I. End-On	1. Deferment of decision to be a teacher. 2. No distraction from study of biology as a pure science. 3. Self-contained year of pedagogy. 4. Alternative profess-	1. A "pure" science approach with little social science content. 2. Most of programme taught by scientists and not educationalists.

Model	Strengths	Weaknesses
	ions available after three years of research biology	3. Emphasis on preparing for a career in biology rather than teaching. 4. Pedagogical strand taken almost as an "after thought". 5. Teaching practicum usually in block release.
II. Concurrent	1. Biology and pedagogy develop in parallel strands. 2. More opportunity for long term pedagogical studies eg. a social issue studied over several semesters. 3. More likelihood of biologists and science educators working in cooperative teams. 4. Teaching practicum more likely to spread over the school year. 5. Greater opportunity for extended field studies and visits (eg. over vacations).	1. Biological content continues to be taught by scientists and not educationalists. 2. Early commitment to teaching. 3. Cross-faculty administration with complex management. 4. While team building possible it is difficult as science educators are frequently given a lower status than pure scientists. 5. Because content weighting is in favour of pure biology and not pedagogy educational strand is sometimes denigrated by students. 6. Studies of the social impact of biology usually left to the pedagogical strand and frequently under emphasised due to lack of time.
III. Sandwich	1. Biological content and pedagogy build alternately. 2. Extended practicum possible. 3. Work experience can	1. Biological content usually (but not always) continues to be taught by scientists rather than educationalists.

Model	Strengths	Weaknesses
	be built in. 4. Greater opportunity for a study of applied biology. 5. Better access to the community for studies of social issues. 6. Management aspects easier than for the concurrent model because the alternating strands may be separately administered.	2. Early commitment to teaching (but early drop-out facilitated for those not suited for teaching). 3. Team building difficult because of alternating staffing. 4. Emphasis still remains on pure science and social implications are left to the pedagogical strands. 5. Because of the greater opportunity for classroom experience students tend to value the pedagogical strands more highly than for models I and II.
IV. Fully Integrated	1. All elements taught by the same team led by science educators. 2. All aspects can be treated pedagogically. 3. Methods appropriate for social studies can be readily built in. 4. Flexible approach to the practicum possible. 5. Community involvement easier to organize. 6. Social issues can be emphasized.	1. Criticized by scientists as not reflecting the needs of the discipline. 2. Staff need to be well qualified in (i) biology (ii) pedagogy and (iii) social studies. 3. Administration complex to provide necessary flexibility. 4. Additional science laboratories and other science resources needed apart from those provided for courses offered by a faculty of science.

It is clear from Table 18.3 that the most appropriate model for socially-oriented biology is the fully integrated approach (Model IV) taught by a team under the management and supervision of science educators rather than pure scientists. It is an accident of history which has led to the retention of pre-service education of biology teachers within faculties of science. That historical situation was that at one time, and even recently, some school systems perceived that the role of school biology was to prepare students for further studies of biology at post-secondary institutions. This is now totally anomalous. Schools do not often teach subjects such as psychology, bricklaying, or architecture. These programmes are left until the post-secondary years. So why should "biology" be taught as such? What is needed at school level instead is "social" biology with a general educational role.

The specialized needs of the very few students who may wish to enter a biology-based profession should not determine the nature of the school biology curriculum. If school biology is viewed in this way the preparation of school biology teachers is more logically the province of specialized science educators rather than pure scientists and the integrated model is thus most appropriate. That is not to say scientists should not have a role in teacher education. They can be valuable members of a teaching team and can contribute much to teacher development provided their contributions are under the supervision and management of the teacher education institution. The emphasis shifts from pure science to socially relevant science for general education.

18.3 Teaching Methods in Pre-Service Teacher Education

As has been stressed several times in this volume the repertoire of teaching skills required for socially-oriented biology is broader than for the conventional "pure" science approach or even for an "applied" approach. Many of the methods once thought of as the exclusive province of the social sciences are now relevant to the teaching of biology and should be developed in any programme of pre-service teacher education (3). The science oriented competencies listed in Table 18.1 remain valid and should be developed but socially-oriented inter-personal and group skills are also critically important if socially-oriented biology is to be effectively implemented. The following Table (Table 18.4) lists some of the teaching methods needed. For definitions, descriptions and examples of these methods see the present author's monograph on this topic published by ISMED University of the Philippines (4).

Table 18.4. Teaching Methods Especially Appropriate for Socially Oriented Biology

Method	Comment (5)
I. Small Group Work Tutorial Seminar Guided discussion Leaderless discussion Syndicate discussions Brainstorming Case study analysis Debate Group-on-group Nominal group Cross-over groups Mirror-groups Sensitivity groups Learning cells Reflective pairs	If biology teaching is to prepare pupils for life after school it must focus on the development of certain social skills. Three aspects of work in small groups are especially significant in this regard. The first is that interaction in small groups is probably the most frequent social pattern experienced throughout life including experiences in the family circle, in leisure activities and during employment in work teams. School pupils must therefore learn to work in groups: to understand the types and influences of leadership styles; to appreciate the codes of behaviour that make groups effective; to understand their own responsibilities within a group; to understand how group members communicate and to appreciate how groups reach and implement decisions. Secondly, work in small groups focuses responsibility for learning on to the pupil and away from the teacher. Group work is "learner-centred" not teacher centred and so fosters independence, responsibility and self-confidence. The teacher becomes a facilitator rather than merely a source of factual information. Thirdly, modern programmes of biology stress problem solving and a concern for values. An understanding of values and growth in a personal philosophy of life rarely emerge from a teacher-centred classroom. Pupils must have an opportunity to test out their ideas in a non-threatening climate and this is best done by working with groups of their peers. The teacher's task is to monitor and guide growth of these skills and values without imposing a preconceived pattern.

	Method	Comment
II.	Group-Workshops (Laboratory-Based) Experimental Planning Developmental Analytical Evaluative	The practical laboratory session is of course the main-stay of effective biology teaching. There are, however, problems if practical work is concerned only with conveying the "facts" of biology or otherwise restricting its scope to achieving a narrow range of objectives. Important objectives include the processes of science and of the organization and ordering of knowledge. Practical activities therefore need to be carefully planned to achieve both content and process objectives. Some can focus on experimental design and procedure; some on the planning of methods and procedures; others on developmental aspects and others on analytical or evaluative situations. This approach implies a widening of the scope of conventional practical work so that there are participatory "workshop" type activities occurring at all stages of a programme. Frequently a conventional biology "laboratory" is too restrictive for this type of approach and perhaps a general biology "classroom" would be more appropriate allowing for a wide range of activities including the conventional experiment and observation but encouraging other types fo activity such as planning exercises or the production of audio-visual materials.
III.	Simulations, Dramatic and Semi-Dramatic Methods Role play Sociodrama Creative drama Board games Simulated case studies In-Tray or In-Basket Methods Interpersonal games	Simulation and dramatic methods are among the most powerful for achieving objectives of relevance to real life. Unfortunately this whole area is frequently neglected by many biology teachers who quite incorrectly believe that these approaches are more appropriate for the humanities and especially for language arts. Since simulations provide scaled-down simplified models of real-life situations, problems or activities, they provide no-risk settings in which pupils can gain vicarious experience of the real world. This is especially important where real issues are sometimes

Method	Comment
	politically sensitive or highly complex. Well organized simulations encourage objective, emotion-free analysis and can allow the teacher to cut away unnecessary trivia and focus on central issues. The most effective simulations utilize dramatic or semi-dramatic methods but sometimes dramatic methods have value in their own right. They help to establish empathy between individuals and groups and to increase social skills of central importance in day-to-day living. An important aspect of simulation and of dramatic methods is the debriefing phase. Concepts, processes, skills and values emerging from such activities must be made overt by the teacher and thoroughly discussed. All links to the main-stream subject matter of the biology programme must be established and emphasized. Unless these aspects are given strict attention, these methods lose most of their educational significance.
IV. Experiential (on job) Activities Visits and excursions Exchanges Secondments Direct work experience	The term experiential learning has several meanings. In this volume it is taken to mean a form of learning involving the "whole person" in situations outside the confines of the school in real-life on-job situations in the community. There is nothing especially new about the idea of taking pupils into the community on visits, tours and field excursions. What is relatively new, especially in the case of biology, is the more recent emphasis on job-related experiences, even direct "work" experience. In a biology course it goes without saying that the type of work experience that should be explored must relate in some way to the field of biology. That is not to say that it should be limited to laboratories, museums, zoos, botanical gardens and so on, but should include any type of work in which biological principles are involved. Examples could include food

Method	Comment
	processing, agriculture, newspaper work, medicine, publishing, pharmacy, veterinary work, health programmes, broadcasting, family planning or pest control. The most effective and realistic of the various options for experiential learning within school programmes is to help pupils find vacation, afternoon or weekend employment. To be an effective part of the curriculum, however, this work experience must be integrated into the school curriculum. All aspects must be monitored and appraised by means of critical evaluative discussion within relevant school lessons. "Sandwich" programmes involving short blocks of structured work experience interspersed by larger blocks of more formal schooling are a logical extension of this approach. But this may well require some restructuring of school terms and vacations.
V. Micro-Training Methods One-to-one observation and analysis of behaviour Group observation and analysis Audio and video replay	Micro-training had its origins in the micro-teaching movement that emerged in the 1960s. Surprisingly little use has been made of the technique in general teaching and yet it is ideal for fostering the development of practical skills. In biology there is a whole range of such skills, many very transferable to everyday life. These include observation and the recording of observations; measurement skills; skills of handling equipment and so on. By applying micro-teaching techniques more generally, the components of relevant skills could be identified and pupils encouraged to practise these to attain a specified standard. The technique of self-observation by means of video-recording is especially significant here but has had little place in the biology classroom except for the training of teachers. Perhaps it is now time to apply the technique more generally.

	Method	Comment
VI.	Self-Paced Systems Individual reading Programmed reading Linear programmed instruction Branched programmed instruction Creative writing Report writing Computer assisted instruction Programmed media Audio-tutorial Modular instruction Keller Plan (Personalized System of Instruction)	It is axiomatic that if biology teaching is to be effective in preparing citizens to cope with on-going demands of society and promote lifelong learning, it must contribute to their growth as independent learners. By independent learning is meant "learning alone". It involves pupils accepting a degree of responsibility for their own learning at least to the point where the pace or rate of progress is self-controlled. Because independent learning is self-paced it goes some way towards catering to individual differences in ability and interest. There is a wide range of self-paced methods available from simple reading assignments to more sophisticated systems such as the Keller Plan, the audio-tutorial and computer-assisted instruction. Almost all these systems, apart from a conventional reading programme, are based to some degree on the principles of programmed instruction. That is: the learner controls the pace of study; the material is broken into small steps; the learner must make a response after each step, usually by answering questions; the responses are checked by providing immediate answers so that the learner gains instant feedback; and reinforcement is provided by ensuring successful completion of each step. Usually self-paced systems include a pre-test and post-test and employ a mastery approach - that is, attainment of a satisfactory standard on the post-test before moving on to the next unit of work. Self-paced systems can stand alone or be used in combination with other methods of teaching.
VII.	Individualized Instruction Individually prescribed contracts	The most significant aspect of individualized instruction is the careful attention that must be given to diagnosis. If the system is to be effective this has to be very

Method	Comment
Individual Prescribed Instruction (IPI) Cognitive style mapping and individual prescription	comprehensive, covering as many characteristics as possible - ability; personality; preferences and so on. Another important feature is that learners should not only experience the types of activities they prefer but also take part in activities designed to overcome weaknesses and develop a "balanced" personality.

The methods outlined in Table 18.4 above should be employed as the main core of strategies in the pre-service preparation of teachers for socially-oriented biology. The methods then provide exemplars for the students who should be encouraged to use similar methods in their own classrooms.

While inquiry-based participatory practical work remains the cornerstone of effective biology programmes, the types of activities undertaken in laboratories and out-of-doors need to be broadened to include analytical, synthesizing, planning, developmental and evaluative experiences in addition to the more conventional descriptive and experimental procedures. The biggest changes, however, involve the incorporation of a wide range of small group activities; dramatic and semi-dramatic methods; educational games and simulations; on-job experiential learning and various forms of independent learning.

The ideal approach would be to cater to differences in interests, abilities and learning styles by totally individualizing the methods used in a range of instructional options. These options could be organized, perhaps, by some form of contract learning. Any effective teaching programme, however, utilizes a wide variety of teaching methods. These methods should be chosen to optimize achievement of relevant objectives and to meet the needs of individual learners. The types of objectives to be achieved by school biology today must reflect the objectives of the community at large. It should be stressed too that the needs of today's students are largely social needs. The more biology teaching can be broadened to meet these objectives and to accommodate these needs, the more effective and widespread will be its impact. This is the major challenge for teacher educators.

18.4 In-Service Teacher Education

The change-over from conventional to socially-oriented biology is a world trend but is more advanced in some school systems than others. It is an inevitable innovation in the face of a changing, better informed and more aware community which demands accountability in terms of relevance from its educational system. Teachers, therefore, need to be prepared for this change and if an educational system accepts and plans for the change the new approaches will be implemented smoothly and effectively.

As part of this planned change there needs to be major programmes of in-service education to re-orient teachers to the new objectives, content and methodologies involved. There are several modalities for in-service education and these are summarised in the following table (Table 18.5).

Table 18.5. Modalities for the In-Service Education of Teachers

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1. Academic Model: Institution of higher education either in home country or abroad (eg. university) provides part time and/or full time postgraduate diplomas, masters degrees and doctorates in specialized areas of education.

   Advantage: Specialists trained.
   Disadvantage: Expensive and terminal.
   Comment: Not in-service in the strict sense since not continuous throughout professional career. Valuable for developing specialized skills for senior professional staff.

2. Accreditation Model: Employer provides training to upgrade status or for changed role, eg. headteacher to inspector.

   Advantage: Career paths facilitated.
   Disadvantage: Closed programmes
   Comment: Not in-service in the strict sense since not continuous throughout professional career.

3. Pre-Service Extension Model: A special unit within a pre-service training institution accepts responsibility for in-service.

   Advantage: Resources readily available.
   Disadvantage: Pre-service and in-service have different objectives and methods.
   Comment: Pre-service staff must be especially trained for in-service.

4. Inspectorial Model: Inspectors accept responsibility for in-service activities in schools.

   Advantage: Network in place.
   Disadvantage: Conflict between roles.
   Comment: Must be complemented by other modalities.

5. Curriculum Change Model: Curriculum division prepares teachers for new courses and textbooks.

Advantage: Facilitates official changes.
Disadvantage: Teachers become dependent.
Comment: Has been abandoned in many countries because teachers tend to wait for an in-service course before taking action about new courses and textbooks.

6. Teacher Centre/In-Service Centre Model: Teachers attend activities/courses provided by staff of an in-service centre.

Advantage: Training in hands of in-service specialists.
Disadvantage: Costly and disruptive to school routine.
Comment: Valuable for carefully defined categories of teachers.

7. Community Centre Model: Teachers attend activities/courses provided by an adult education/continuing education centre.

Advantage: Facilitates school/community relations.
Disadvantage: Concerns may differ.
Comment: Especially valuable in remote areas - successful with hill tribes of Thailand and in remote areas of Nepal.

8. Hierarchical Model: One level of an educational system accepts responsibility by providing in-service activities for the level below, eg. upper secondary for junior secondary, junior secondary for upper primary, and so on.

Advantage: Teachers help teachers.
Disadvantage: Goals not compatible.
Comment: Only marginally successful unless activities focus on areas of common interest and concern.

9. Task Force Model: Groups of experts in particular fields visit individual schools or cluster schools to provide training.

Advantage: Direct training in specialized areas.
Disadvantage: Expensive.
Comment: Especially valuable in developing practical skills.

10. Self Instructional Model: Individuals or groups of teachers study units of work usually made available through distance education.

Advantage: Meets needs of individuals.
Disadvantage: Expensive.
Comment: While expensive, highly cost effective. Can be supplemented by mass media.

11. School Cluster Model: Neighbouring schools work together to provide self-help programmes.

Advantage:	Economical and stresses self reliance.
Disadvantage:	Transport and organizational problems.
Comment:	School cluster needs external support. Especially useful for production of teacher-made resources and for sharing ideas.

12. School Based Model: Each school accepts responsibility for self-help programme provided by its own staff.

Advantage:	Continuous programme.
Disadvantage:	Depends on level of expertise available.
Comment:	Cannot be sustained without external support.

13. School Focused Model: School based activities strongly supported by a range of modalities directly available to each school.

Advantage:	Meets needs of school.
Disadvantage:	Infrastructure needed.
Comment:	This is the emerging trend. It depends on an educational system with a broad range of in-service modalities.

Each school system has to develop a mix of in-service modalities according to its own needs and circumstances. A long-term innovation such as the change-over from "pure science" to a "socially oriented" approach to biology teaching, however, will require consistent and effective implementation of as many of the modalities as possible. The aim should be to develop a school focused approach with all the modalities supporting school-based activities.

Since most of the changes involved are skills-based the main approach throughout any programme of in-service education, whatever the modality, should be a series of intensive practical workshops. These could be modular in structure and designed on the INPUT - PROCESS - OUTPUT systems model outlined in Chapter 16. The mini-course approach advocated by the present author provides a possible model (6). An example of the programme for a skills-based mini-course on inquiry learning is given below (Table 18.6) (7).

Table 18.6. Example of an In-Service Workshop for Teachers Based on the Minicourse Approach
(After Meyer, Jenkins and Chan 1980)

MINICOURSE M67
INQUIRY LEARNING

Inquiry learning is essentially learning by means of rational problem solving. It is in marked contrast to didactic methods of teaching which involve telling, assignment giving and describing. It is different from the Socratic method which is a question-asking approach where all questions are determined by the teacher.

This minicourse examines the nature and role of inquiry learning in a wide range of contexts.

Purpose:

This course is appropriate for teachers and trainers at all levels and in all disciplines who are interested in making more effective use of inquiry methods.

Aims:

1. To develop a greater appreciation of the significance of inquiry learning as a process in education.
2. To understand the steps involved in the process of inquiry.
3. To review techniques designed to enhance inquiry learning.
4. To develop greater confidence in using inquiry methods in a variety of teaching-learning contexts.

Objectives: After completing the course you should be able to:

1. Define inquiry learning and distinguish it from didactic and Socratic methods.
2. Analyse teacher-learning episodes in terms of their degree of inquiry orientation.
3. Describe a general model of the steps in inquiry learning.
4. Write objectives suitable for students learning to inquire.
5. Plan techniques for promoting the process of inquiry.
6. Plan teaching sequences to develop the skills of inquiry learning.

Programme:

Session I	IPO	Topic and Activity	Grouping
4.30-5.00		Why is problem-solving an effective form of learning?	
	I	*Introductory talk*	General session
5.00-6.30		Characteristics of inquiry learning.	
	P O	*Workshop in which participants gather data, formulate hypotheses and design an approach to solving a problem*	Small groups (3-5)
6.30-7.30		DINNER	
7.30-8.15		Definition of inquiry	
	I	*(i) Groups report on findings from previous workshop*	General session
	P	*(ii) Discussion to derive definition of inquiry*	
	O	*(iii) Formulation of definitions*	
8.15-9.00		Classification of teaching episodes	
	I	*Participants analyse written case studies of teaching episodes and (P) classify them by degree of didactic, Socratic and inquiry methods involved*	Small groups (3-5)
9.00-9.30		Steps in the inquiry sequence	
	O	*Presentation and discussion of a general model*	General session

. . . .

Session II			
4.30-5.15		Techniques for promoting the processes of inquiry	
	I	*Workshop in which participants derive methods of enhancing learners' skills in the processes of inquiry*	Small groups (3-5)
5.15-6.00		Evaluation of techniques	
	P	*Presentation and (O) evaluation of reports from previous workshop*	General session
6.00-6.30		Writing objectives for inquiry learning	
	I	*Talk reviewing printed materials*	General session
6.30-7.30		DINNER	
7.30-8.30		Planning a unit of work involving inquiry learning	
	P	*Workshops in which participants plan learning sequences*	

		and prepare for five minute simulated presentations	Groups of 5
8.30-9.15		Evaluation of presentations	
	O	*Each group presents a five minute teaching episode to be discussed by all participants*	General session
9.15-9.30		Practical problems of implementing program	
		General discussion	General session
		. . . .	

Note: I = Input
P = Process
O = Output

The type of tightly structured workshop outlined in Table 18.6 would be especially appropriate for developing skills such as case study analysis; design and conduct of a social survey and so on. It is especially useful and effective for developing skills in the types of teaching methods required for a socially oriented approach including the methods listed in Table 18.4.

18.5 Conclusion

The trends outlined and reviewed in this volume are not theoretical. They represent on-going innovations and are indicators of gradual evolution in the teaching of school biology which has shifted the orientation very much away from a comfortable "subject matter" approach towards something with direct social meaning. This presents a major challenge for biology teachers.

Pre-service teacher educators should understand, anticipate and respond to the change. They above all have the future of the school learners in their hands through the development of future oriented, concerned and flexibly-minded teachers. Hopefully this volume will be of assistance in this regard.

Teachers educated before the changes began are in urgent need of in-service support and even recently qualified teachers may not be fully aware of the rapid rate of change occurring in this area. Administrators, therefore, need to strengthen all aspects of in-service education for all categories of biology teachers.

Indeed it is perhaps time for a major up-grading of the biology teaching profession at all levels. One way of achieving this is to provide staff development programmes for teacher educators and this is to be the focus of a new (1991) project of the Education Commission of the International Union of Biological Sciences.

Whatever else happens one thing is clear, the changes in emphasis cannot now be reversed. School biology enters the next millenium with a new look which will focus on real-world needs and which will aim to improve the quality of life for all.

Notes and References

(1) Unesco: Unesco Handbook for Biology Teachers in Asia. Paris: Unesco 1986 pp 141-145

(2) Meyer, G. Rex (Ed) Overcoming Constraints on the Teaching of Biology A Global Perspective. Jakarta: Unesco Regional Offices for Science and Technology in South East Asia (UNESCO-ROSTEA) 1988 pp 59-60

(3) Meyer, G. Rex Strategies for Improving the Social Effectiveness of Biological Education at School Level - with Special Reference to Innovative Methods of Teaching (Occasional Paper No 4). Quezon City Philippines: Institute for Science and Mathematics Education Development (ISMED) University of the Philippines 1983 18 pp

(4) Ibid.

(5) Extracts from Meyer, G. Rex, Ibid.

(6) Meyer, G. Rex "The Development of Minicourses (with a Basis in Educational Technology) for the In-Service Education of Teachers and Trainers" Programmed Learning and Educational Technology Vol 16 No 1 February 1979 pp 23-37

(7) Meyer, G. Rex; Jenkins, Carole; and Chan, Evalina Catalogue of Minicourses for Teachers and Trainers. North Ryde Australia: Macquarie University Continuing Education Program 1980 pp 100-101

RECOMMENDED

READING

Recommended Reading

The following is not a cumulative list of the references given at the end of each chapter, although some of the more significant of those references are included. The aim is to provide information relevant to the overall trends and issues raised in this volume.

I. Publications by Unesco

There are several series of Unesco publications which are directly relevant to modern approaches to the teaching of biology, especially stressing applied and societal aspects.

(a) Unesco Regional Handbooks

Unesco Handbook for Biology Teachers in Asia. New Delhi: Unesco Regional Office of Science and Technology for South and Central Asia 1986 606 pp

Unesco Handbook for Biology Teachers in Africa. Paris: Unesco 1986 329 pp

Unesco Handbook for Biology Teachers in Latin America. Montevideo: Unesco Regional Office for Science and Technology for Latin America and the Caribbean (ROSTLAC) 1982 253 pp

These three volumes contain useful guidelines on curriculum design and development, on the production of resources and on teaching methodologies. While the focus in each volume is on the particular needs and concerns of a specific region all contain information of more general application. There are excellent examples of social issues studies and of suitable socially oriented case studies.

(b) Unesco Source Books

Unesco Source Book for Science Teaching. Paris: Unesco 1956 222 pp

New Unesco Source Book for Science Teaching. Paris: Unesco 1973 270 + 1 pp

Unesco Sourcebook for Out-of-School Science and Technology Education 1986 202 pp

While these volumes cover all aspects of science they contain a great deal of useful information of direct relevance to biology. The main focus is on the design, construction and use of low cost science equipment. The emphasis is on science aspects of laboratory and field work.

(c) New Trends in Science Education Series

Of the many books in this series the following are of direct relevance to the theme of the present volume. All are published by the Paris office of Unesco.

New Trends in Biology Teaching
Vol IV 1977 235 pp
Vol V 1987 222 pp

New Trends in Integrated Science Teaching
Vol IV 1977 199 pp
Vol V 1979 238 pp
Vol VI 1990 238 pp

Trends in Environmental Education
1977 244 pp

New Trends in the Utilization of Educational Technology for Science Education
1973 270 pp

This series reviews current trends and gives up-to-date examples and case studies of exemplary teaching. Volume V of the Biology series contains some very relevant examples of biology-based social issues and a useful chapter on games and simulations. The volume on educational technology remains a key reference on the use of audio-visual media and systems.

(d) Innovations Series

The following three volumes are published by Unesco Paris and are edited by Dr David Layton.

Innovations in Science and Technology Education
Vol I 1986 188 pp
Vol II 1988 299 pp
Vol III 1990 247 pp

These three books provide useful overviews of world trends. Volume III focuses on assessment and on national examination systems.

Also See:
Baez, Albert V. Innovation in Science Education World Wide.
Paris: The Unesco Press 1976 249 pp

This includes an excellent overview of the systems approach advocated in this present volume and how it entered education.

(e) Science and Technology Education Document Series (STEDS)

This series is produced by Unesco's Section of Science and Technology Education. Of the almost forty titles produced so far the following are most relevant to the theme of this volume.

1. Glossary of Terms Used in Science and Technology Education 1981 (English)
2. Methodologies for Relevant Skill Development in Biology Education 1982 (English)
3. Nutrition Education: Curriculum Planning and Selected Case Studies 1982 (English) (Reprint in Nutrition Education Series No 4)
4. Technology Education as Part of General Education 1983 (English and French)
5. Nutrition Education: Relevance and Future 1982 (English) (Reprint in Nutrition Education Series No 5)
7. Encouraging Girls into Science and Technology Education: Some European Initiatives 1984 (English)
8. Genetically-Based Biological Technologies 1984 (English)
9. Biological Systems, Energy Sources and Biology Teaching 1984 (English)
10. Ecology, Ecosystem Management and Biology Teaching 1984 (Reprint 1986) (English)
11. Agriculture and Biology Teaching 1984 (English)
12. Health Education and Biology Teaching 1984 (English)
15. Human Development and Evolution and Biology Teaching 1985 (English)
16. Assessment: A Practical Guide to Improving the Quality and Scope of Assessment Instruments 1986 (English)
17. Practical Activities for Out-of-School Science and Technology Education 1986 (English)
18. The Social Relevance of Science and Technology Education 1966 (English)
19. The Teaching of Science and Technology in an Inter-disciplinary Context 1986 (English)
22. Leisure, Values and Biology Teaching 1987 (English and French)
23. Use of Sea and its Organisms 1987 (English)
25. Biology and Human Welfare. Case Studies in Teaching Applied Biology 1988 (English)
26. Sourcebook of Science Education Research in the Caribbean 1988 (English)
28. Microbiological Techniques in School 1988 (English)

29. Games and Toys in the Teaching of Science and Technology 1988 (English and French)

30. Field Work in Ecology for Secondary Schools in Tropical Countries 1988 (English, Arabic)

31. Educational Materials Linking Technology Teaching with Science Education: Technology in Life 1988 (English)

33. Systems Thinking in Biology Education 1989 (English)

36. Bibliography in Integrated Science Teaching 1990 (English)

38. The Teaching of Science and Technology in an Interdisciplinary Context 1990 (English)

39. Teaching Biotechnology in Schools 1990 (English)

The special value of this series is the overview provided of exemplary practice. All volumes review latest trends and give helpful examples. Throughout the series there is a focus on applied aspects and there are many examples of biology-based social issues.

(f) Other Relevant Publications by Unesco

Asian Programme of Educational Innovation for Development (APEID). Bangkok: Unesco Regional Office for Education in Asia and Oceania/The Pacific:
Low-Cost Educational Materials How to Make How to Use How to Adapt:
Inventory Vol I 1980 158 pp
Inventory Vol II 1982 117 pp
Inventory Vol III 1984 117 pp

APEID. Linking Science Education to the Rural Environment - Some Experiences Report of a Regional Mobile Field Operational Seminar, Philippines and India, 13 August-2 September 1979. Bangkok: Unesco Regional office for Education in Asia and Oceania 1980 77 pp

APEID. Science in Basic Functional Education. Philosophy Approaches, Methods and Materials Report of a Preparatory Working Group Meeting Seoul Republic of Korea, 7-12 July 1975. Bangkok: Unesco Regional Office for Education in Asia 1975 49 pp

APEID. Implementing Curriculum Change A Symposium of Experience from the Asian Region Bangkok Thailand 6-18 September 1986. Bangkok: Asian Centre of Educational Innovation for Development Unesco Regional Office for Education in Asia 1976 62 + 3 pp

APEID. Curriculum Development: Linking Science Education to Life Report of a Sub-regional Workshop on Designing and Developing Innovative Science Curriculum and Instructional Materials Bangkok, 8-20 December 1980. Bangkok: Unesco

Regional Office for Education in Asia and the Pacific 1981 74 pp

APEID. Developing Material for Biology Teaching A Report of a Sub-regional Workshop Bangkok, 3-12 August 1981. Bangkok: Unesco Regional Office for Education in Asia 1982 32 pp

Faure, Edgar et al. Learning To Be the World of Education Today and Tomorrow. Paris: Unesco 1972 313 pp

Hernandez, Dolores, F., and Basnayake, Valentine Some Thoughts on Biology Education: Strategies and Methods for Teaching/Learning Biology for General Education and Notes for Discussion on Content of Secondary School Biology (APEID Occasional Papers INF 26 No 5). Bangkok: Unesco Regional Office for Education in Asia 1981 46 pp

Unesco: Population Education: a Contemporary Concern. Paris: Unesco 1978 120 pp

Unesco: "Environmental Education in Asia and the Pacific" Bulletin of the Unesco Regional Office for Education in Asia and the Pacific No 22 June 1981 328 + 62 pp

Unesco: "Population Education in Asia and the Pacific" Bulletin of the Unesco Regional Office for Education in Asia and the Pacific No 23 June 1982 348 + 70 pp

Unesco: "Science Education in Asia and the Pacific" Bulletin of the Unesco Regional Office for Education in Asia and the Pacific No 25 June 1984 500 + 51 pp

II. Publication by Unesco in Cooperation with the International Union of Biological Sciences Commission for Biological Education (IUBS-CBE)

Meyer, G. Rex (Ed) Overcoming Constraints on the Teaching of Biology A Global Perspective. Jakarta: Unesco Regional Office for Science and Technology in South East Asia (UNESCO-ROSTEA) 1988 482 pp

A world overview of approaches to secondary school biology teaching in the mid 1980s is provided. There are essays reviewing broad issues such as curriculum development, teacher education and assessment. This book provides a useful background to the present volume since the early trends towards social orientation are summarised and reviewed.

III. Publications of the International Union of Biological Sciences Commission for Biological Education (IUBS-CBE)

Since 1980 IUBS-CBE has produced several volumes on the teaching of biology of relevance to the relationship between biological science and society. Of these the following are most directly applicable. They are arranged in order by publication date.

For information about these publications contact: Professor G. Schaefer, Chairman IUBS-CBE, Faculty of Education, University of Hamburg, Von-Melle-Park 8, D-2000 Hamburg 13, Federal Republic of Germany.

Kelly, Peter J. and Schaefer, Gerhard (Eds) Biological Education for Community Development. London: Taylor and Francis 1980

Atchia, Michael Research in Community-Based Biological Education 4 Case-Studies. Reduit Mauritius: IUBS-CBE 1982 124 pp 191 pp

Kelly, Peter J. (Ed) "Environmental Education Through Biology Report of a Symposium Organized During the General Assembly of IUBS at Ottawa, 1982" Biology International Special Issue No 3. Paris: IUBS 1983

Meyer, G. Rex and Rao, A.N. (Eds) Teaching Science Out-of-School. Singapore: IUBS-CBE and the Asian Network for Biological Sciences 1984 162 pp

Kelly, Peter (Ed) Six publications in the series "Biology and Human Welfare". Paris: Unesco 1983-1985

Schaefer, Gerhard and Hernandez, Dolores (Eds) Health Education Through Biology Teaching. Quezon City Philippines: Institute for Science and Mathematics Education Development (ISMED) University of the Philippines 1985 66 pp

Schaefer, Gerhard and Younes, Talal (Eds) "New Challenges for Biological Education" Biology International Special Issue No 11. Paris: IUBS 1986

Crovello, T.J. (Ed) Computer and Biological Education, The Expanding Universe (IUBS Monograph Series No 5). Paris: IUBS 1988 178 pp

Meyer, G. Rex (Ed) Selected Issues in Biological Education Papers Submitted to an International Seminar of IUBS-CBE Sydney 1988. Hamburg: Lit 1990 160 pp

Meyer, G. Rex (Ed) Bioethics in Education. Hamburg: Lit for IUBS-CBE 1991 190 pp

Atchia, Michael and Rugumayo, Edward (Eds) Biological Education for Sustainable Development. 1991 in preparation

Schaefer, Gerhard (Ed) Biological Education for Future Human Needs 1991 in preparation

The above series presents the latest thinking world-wide on many aspects of biology education. The Commission has been especially concerned to develop biology education which caters for human needs. It has therefore produced volumes dealing with community development, the quality of human life and the analysis of societal issues. The work of the Commission is strongly represented throughout the present volume.* It should also be noted that IUBS-CBE works closely with Unesco. Several publications in the New Trends series and the Science and Technology Education Document Series listed above have been produced for Unesco by members of the Commission.

IV. Bangalore Conference Publications

Series: Science and Technology and Future Human Needs General Editor John Lewis. London: Published for the ICSU Press by Pergamon Press 1986-1987

Vol 1 Lewis, John L. and Kelly, P.J. Science and Technology Education and Future Human Needs 185 pp

Vol 2 Frazer, M.J. and Kornhauser, A. Ethics and Social Responsibility in Science Education 264 pp

Vol 3 Waddington, D.J. Education, Industry and Technology 365 pp

Vol 4 Graves, Norman J. Land, Water and Mineral Resources in Science Education 312 pp

Vol 5 Kelly, Peter J. and Lewis, John L. Education and Health 296 pp

Vol 6 Rao, A.N. Food, Agriculture and Education

Vol 7 Kirwan, D.F. Energy Resources in Science Education 214 pp

Vol 8 Baez, A.V.; Knamiller, G.W.; and Smyth, J.C. The Environment and Science and Technology Education 430 pp

Vol 9 Taylor, Charles Science Education and Information Transfer 230 pp

The Conference on Science and Technology and Future Human Needs held in Bangalore India in August 1985 was one of the most significant events in science education in the 1980s. It was attended by well over 300 science educators from all regions of the world. The Conference was sponsored by the Committee for Science Teaching of the International Council of Scientific Unions (ICSU-CTS) with support from Unesco. The volumes listed above summarize the main outcomes of the Conference. They focus on the relationships between science and society and contain guidelines and practical examples of approaches relevant to secondary school biology.

V. Additional Reading

Becker, James M. (Ed) Schooling for a Global Age. New York: McGraw Hill 1979 345 pp

A systematic analysis of approaches to international education. Valuable background reading for teachers of socially oriented biology.

Bloom, Benjamin S.; Hastings, J. Thomas; and Madaus, George F. et al. Handbook on Formative and Summative Evaluation of Student Learning. New York: McGraw-Hill 1971 923 pp

This volume remains one of the key references on curriculum design and assessment. The chapter by Leopold Klopfer on "Evaluation of Learning in Science" (pp 559-641) is especially relevant.

Committee on High-School Biology Education Board on Biology Commission on Life Sciences National Research Council Fulfilling the Promise Biology Education in the Nation's Schools. Washington DC: National Academy Press 1990 152 pp

A valuable review of the present (1990s) status of school biology in the USA. The trend towards teaching biology for social relevance is emphasised.

Gilbert, Peter G.S. and Lovegrove, M.N. (Eds) Science Education in Africa a Report of the Sixth Leverhulme Inter-University Conference in Africa held at Chancellor College of the University of Malawi Limbe, Malawi, in March 1968. London: Heinemann 1972 243 pp

An interesting and useful review of the status of biology teaching in Africa through the 1960s. Emerging interests in social relevance, science education for national development, and the significance of traditional practice is evident.

Meyer, G. Rex Strategies for Improving the Social Effectiveness of Biology Education at School Level - with Special Reference to Innovative Methods of Teaching (Occasional Paper No 4). Quezon City Philippines: Institute for Science and Mathematics Education Development (ISMED) University of the Philippines 1983 18 pp

Definitions, descriptions and examples of a range of strategies and methods appropriate for the new socially oriented approach to school biology teaching. Strategies reviewed include small group work; group workshops; simulations; dramatic and semi-dramatic methods; experiential activities; micro-training; independent self-paced systems and individualized instruction.

Morholt, Evelyn; Brandwein, Paul F.; and Joseph, Alexander A Sourcebook for the Biological Sciences Second Edition. New York: Harcourt, Brace and World 1966 795 pp

Probably the most comprehensive and well organized text on science aspects of the teaching of biology. While it naturally reflects the status of biology in the 1960s it contains invaluable practical suggestions on dealing with the main concepts of biology as a discipline.

Romey, Bill Confluent Education in Science. Canton New York: Ash Lad Press 1976 121 pp

The author argues for a strengthened relationship between the cognitive and affective domains in the teaching of science. Useful practical guidelines are provided.

Simon, Sidney B.: Howe, Leland W.; and Kirschenbaum, Howard Values Clarification a Handbook of Practical Strategies for Teachers and Students. New York: Hart 1972 397 pp

This valuable collection of practical suggestions for classroom activities should be on the bookshelf of every teacher interested in promoting a social issues approach to teaching.

Voss, Burton E., and Brown, Stanley B. Biology as Inquiry A Book of Teaching Methods. Saint Louis: C.V. Mosby 1968 239 pp

This remains one of the most useful of the references on methods of teaching biology. The coverage, while reflecting the stage of development in biology education in the 1960s, contains useful practical advice for practising teachers.

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